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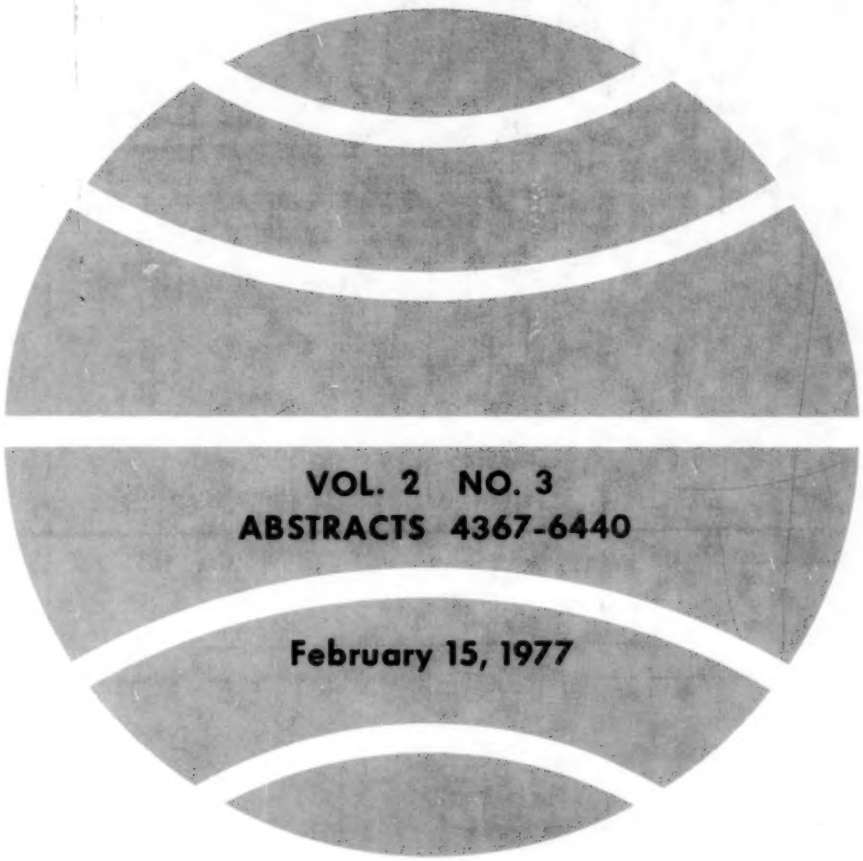

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**Ackley, M.H.,** *See* Derr, V.E., 1:17257
**Acton, J.P.,** *See* Mitchell, B.M., 1:16369
**Adam, J.C.,** *See* Gitomer, S.J., 1:18301
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Volume 2, Number 3, February 15, 1977

# ERDA ENERGY RESEARCH ABSTRACTS

## COAL AND COAL PRODUCTS

**4367** (PB—243151) **Northern Great Plains resource program, Mineral Resources Work Group report.** (Northern Great Plains Resources Program, Denver, Colo. (USA)). Feb 1974. 225p. (NGPRP/CD—74/300). NTIS $7.25.

Prepared in cooperation with Department of Agriculture, Washington, D.C., Department of the Interior, Washington, D.C., and Environmental Protection Agency, Washington, D.C. See also PB—243150 and PB—243152.

The report discusses coal development, resources, legislation, chemistry, current and potential coal mining methods, effects of surface and underground mining, and constraints to increased coal production. The noncoal mineral resources within the Northern Great Plains are discussed and conclusions and recommendations for areas of additional investigation are listed. (GRA)

**4368** **170th American Chemical Society national meeting, Chicago, Illinois, August 24—29, 1975. Abstracts of papers.** Baltimore; Port City Press, Inc. (1975). 747p. (CONF-750806—(Absts.)). $9.00.

From 170. American Chemical Society national meeting; Chicago, Illinois, USA (24 Aug 1975).

**4369** **172nd American Chemical Society national meeting, San Francisco, California, August 29—September 3, 1976. Abstracts of papers.** Baltimore; Port City Press, Inc. (1976). 1098p. (CONF-760826—(Absts.)).

From American Chemical Society meeting; San Francisco, California, United States of America (USA) (29 Aug 1976).

**4370** **Overview of international health-safety-extraction research and development in coal mining.** Yancik, J.J. *Min. Congr. J.*; **62**: No. 8, 51-58(Aug 1976).

An overview of research programs in coal mining is given with summary information for major countries and tabular data for 20 countries (institutes, major programs and specialties, sponsor, personnel, and budget). Cooperative multilateral and bilateral agreements in this area are discussed briefly. These include exchange of delegations, ongoing cooperation in particular areas, exchange of information, and exchange of personnel, equipment, and research material. The activities of the International Committee for Coal Research are reviewed. (LTN)

### PROCESSING

*REFER ALSO TO CITATION(S) 5226*

#### CARBONIZATION

*REFER ALSO TO CITATION(S) 4374, 4375, 4400*

**4371** **Evaluation of coal blends containing antifissuring agents for cokemaking.** Reeve, D.A.; Paulencu, H.N. (Canadian Center for Mineral and Energy Technology, Ottawa). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

In the face of dwindling sources of prime low-volatile coking coals, the CCRA undertook a study in 1972 to determine the feasibility of adding inert carbonaceous materials, antifissurants, to inferior blends to make high-quality metallurgical coke. Although several antifissurants have been used to reduce the requirements of low-volatile coal, this paper is mainly concerned with the potential use of pulverized coke screenings (coke fines). The tests have shown that coke fines can be used in the coke oven blend to make coke of acceptable strength for blast furnace use. The coke quality is influenced by the quantity and size consist of the coke fines added and by the coke oven operating conditions.

**4372** **Inland's preheat-pipeline charged coke oven battery.** McMorris, C.E. (Inland Steel Co., East Chicago, Indiana). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

Inland's supply of high volatile coal comes from southern Illinois, and, while the chemistry of the coal is excellent because of good preparation practices, the use of a high percentage of it in the coal mix is not conducive to suitable coke stability in conventional ovens. The other coal in the mix is a medium volatile coal. Preheating a coal mixture before charging into a slot oven will increase the stability of the resultant coke. The need for higher stability coke dictated that preheating tests be run. The results were that the proposed mix could be pipelined, and the stabilities were satisfactory.

**4373** **Tests on formed coke made by the H.B.N. process in the blast furnaces of the Usinor Company.** Burteaux, M.; Lescour, M.; Lesur, M.; Cordier, M.; Soubrier, M. (Usinor, Longway, France). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

Research by the Houilleres du Bassin du Nord and du Pas-de-Calais on formed coke has led to the development of a production process in an industrial unit which has produced about 40,000 tonnes of coke. A number of tests have been carried out in the blast furnaces of the USINOR Company at Longwy, Denain and Dunkerque. This paper gives a review of the situation.

#### DESULFURIZATION AND PURIFICATION

*REFER ALSO TO CITATION(S) 5481*

**4374** **Development of coke breeze recycling at Clairton.** Larimer, T.M.; McGinness, J.P.; Shoenberger, R.W. In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

Two years ago a new process for recycling and upgrading of minus 3/16-inch coke fines was installed at the Clairton Works Coke Plant of the United States Steel Corporation. This process involves the use of a cage mill for sizing the coke dust. The objectives of this project included a lowering of material cost through the use in the coal mix of low-cost, minus 3/16-inch coke breeze; i.e., coke dust, the substitution of prepared coke dust for low volatile coal which is costly and in short supply, and an increase in coke yield and in furnace coke production by use of a material with minimum volatility as a coal replacement. The initial carbonization tests in pilot scale ovens and the later tests in full scale plant ovens which led to the selection of a cage mill are described.

In addition, the plant facility and its operating characteristics are discussed.

**4375 Ironmaking conference. Proceedings of the 34th conference held at Toronto, Ontario, Canada, April 13-16, 1975.** Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975). 641p.

Forty-one papers by various authors are given in the annual proceedings volume. Subjects covered are: blast furnace energy; sintering raw materials; coal and coking; review of direct reduction technology; pushing emissions control; blast furnace fuel injection; charging emissions control; blast furnace theory; desulphurization of hot metal; pelletizing raw materials; blast furnaces around the world; and treatment of coke oven gas. Individual papers are abstracted separately.

**4376 Assessment of technologies for the desulfurization of coke oven gas.** Massey, M.J.; Dunlap, R.W. (Carnegie-Mellon Univ., Pittsburgh). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

Recent developments in the technology and economics of COG desulfurization and sulfur recovery are discussed. Particular emphasis is placed on: U.S. marketing of an $NH_3$-based desulfurization system (developed by Firma Carl Still, Germany); improvements in the desulfurization efficiency of the vacuum carbonate system; processing for the production of sulfuric acid from COG $H_2S$; status of techniques for coping with HCN-related processing and effluent discharge problems, and impact of desulfurization plant size, sulfur removal efficiency, and the form of sulfur recovery on process economics.

**4377 Coke oven gas desulfurization using the Sulfiban Process.** Singleton, A.H.; Batterton, G. (Bethlehem Steel Corp., Pittsburgh). In Ironmaking conference. Lourie, D. (ed.). (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

The results of a joint pilot plant program in cooperation with the Bethlehem Plant and with the engineering firm Black, Sivalls and Bryson (BS and B) have shown conclusively that monoethanolamine (MEA) scrubbing is an efficient and effective method for desulfurizing coke oven gas. Total sulfur levels of as low as 10 grains/100 cu ft of cleaned coke oven gas were attained routinely in the 500,000 SCFD demonstration unit. The test results showed that the potential problem of solution fouling due to the formation of thiosulfate and thiocyanate can be avoided by controlling the ammonia concentration in the gas stream. Furthermore, the ease of operation and the fact that this process solves the coke oven gas desulfurization environmental problem without partially converting an air pollution problem to a water pollution problem leads the authors to believe that MEA scrubbing will become a preferred means for coke oven gas desulfurization.

## GASIFICATION

*REFER ALSO TO CITATION(S) 4416, 4635, 4637, 4640, 4646, 4852, 4858, 4861, 4949, 5109*

**4378** (CONF-760817—6) **Two-dimensional studies of coal pyrolysis: preliminary results.** Forrester, R.C. III. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-eng-26. 26p. Dep. NTIS $4.00.

From 2. underground coal gasification symposium; Morgantown, West Virginia, United States of America (USA) (10 Aug 1976).

Two-dimensional pyrolysis behavior of large, instrumented blocks of subbituminous coal has been examined recently in support of in-situ coal gasification process development. Pyrolysis studies have traditionally dealt with small coal particles which were heated rapidly; but, by contrast, in-situ gasification involves slow heating of large coal blocks resulting from permeability enhancement operations or, perhaps, roof collapse. Experiments utilizing maximum reactor temperatures of 500° to 1000°C, achieved over 4- to 50-hr time periods, have produced data correlating tar and gas production rates and composition with maximum temperature and heating rate.

**4379** (CONF-7509137—2) **Coal gasification review.** Loeding, J.W.; Patel, J.G. (Institute of Gas Technology, Chicago, Ill. (USA)). 1975. 22p. Institute of Gas Technology, Chicago, IL.

From Joint power conference; Portland, Oregon, United States of America (USA) (28 Sep 1975).

At present coal gasification appears to be an attractive means of producing an alternative, nonpolluting source of energy. Once this conclusion is accepted, there are several options which need to be considered. Low Btu gas will be chosen for local and power uses, while high Btu gas will be necessary for pipeline distribution (to minimize distribution costs and use the existing nationwide system). In making either of these gases there exist several options. Many gasification processes are being developed and nine are described briefly, with flowsheets. The particular gasification process chosen will be dictated by the specific need at the time of selection, considering the user's assessment of the technological development of the various process options. Economics, the assumed feedstock, and desired operating options will be weighed heavily. Combined-cycle gas turbine-steam turbine power generation probably holds the greatest potential for the use of low-Btu gasification processes. It promises both capital saving and higher efficiencies than conventional coal-fired steam cycles. Many studies have been concerned with combining conventional steam- and gas-turbine power cycles into systems that yield a greater overall efficiency than the individual steam- or gas-turbine systems. (LTN)

**4380** (COO—2904-1) **Chemical and physical stability of refractories for use in coal gasification. First quarterly progress report, 1 May 1976—31 July 1976.** Day, D.E. (Missouri Univ., Rolla (USA)). 3 Aug 1976. Contract E(11-1)-2904. 7p. Dep. NTIS $3.50.

Activities in a program concerned with establishing the corrosion resistance of refractories to environments encountered in coal gasification are summarized. Materials being investigated are calcium aluminate cement and phosphate bonded alumina refractories. The major effort during the report period has been devoted to the modification, construction, and proof testing of the exposure test system, selection and acquisition of raw materials and commercial products, and development of experimental procedures. (JRD)

**4381** (PB—242595) **Economics of air vs $O_2$ pressure gasification of coal. Report on Phase I.** (Fluor Engineers and Constructors, Inc., Los Angeles, Calif. (USA)). Jan 1975. 204p. NTIS $7.25.

Directional economic trends for the alternative use of air or oxygen in coal gasification processes are studied. The processes evaluated are: moving bed, fluidized bed, and entrained bed gasification to produce clean fuel gas. In addition, entrained bed coal gasification is studied in conjunction with a combined cycle power plant. (GRA)

**4382** (PB—243694) **Evaluation of pollution control in fossil fuel conversion processes. Gasification: section 5. BI-GAS process. Final report, Jun 1972—Aug 1975.** Jahnig, C.E. (Chandler Evans, Inc., West Hartford, Conn. (USA)). May 1975. Contract EPA-68-02-0629. 72p. (GRU—9DJ.75). NTIS $4.25.

See also PB—241792.

The report gives results of a review of the Bituminous Coal Research, Inc. BI-GAS Process, from the standpoint of its effect on the environment. The quantities of solid, liquid, and gaseous effluents were estimated, where possible, as well as the thermal efficiency of the process. For the purpose of reducing environmental impact, a number of possible process modifications or alternatives were proposed, and new technology needs pointed out. (GRA)

**4383** (UCRL-Trans—11154) **Gas formation during the combustion of coal in the bed.** Predvoditelev, A.S. Translated from *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk;* No. 10, 1329-1340(1947). 19p. Dep. NTIS $3.50.

Considerable attention has lately been paid in the literature to the problem of gas formation in the coal bed since this problem is of enormous technical importance. An attempt is made to indicate a method that can conveniently be used to arrive at the most essential conclusions concerning the process of gas formation during the combustion of coal in the bed under any conditions.

**4384** (UCRL-Trans—11159) **Surveying method for determining the position of the fire face and the extent of gasification of a coal seam in the Moscow coal basin.** Katsnel'son, N.N. Translated from *Podzemn. Gazif. Uglei;* No. 1, 52-56(1957). 14p. Dep. NTIS $3.50.

Rather complex methods are given for determining the extent of gasification, location of pillars left and the position of the fire force from detailed measurements of the location and extent of ground subsidence. (LTN)

**4385** (UCRL-Trans—11158) **Influence of certain factors on the process of percolation linking of boreholes.** Kreinin, E.V. Translated from *Podzemn. Gazif. Uglei;* No. 4, 28-31(1957). 11p. Dep. NTIS $3.50.

Problems in linking boreholes in preparation for in-situ gasification are discussed. With the countercurrent method using air pressure in one hole and ignition in the other, experimental work has shown that there is a critical flow rate above which movement of the combustion center ceases to increase, but rates

of linking flow in practice have not reached this critical value. The energy of compressing the air for this purpose represents the major cost of linking. In many cases a considerable part of this energy is lost due to the air flow spreading out through the coal seam and even through the roof and floor rocks (rather than being concentrated in the fire channel); this effect is greater when the distance between the holes is greater and when the permeability of the coal seam is low. The volumes of air flow (and not the pressure) is the significant factor. Various experimental linking data are presented in graphs illustrating these effects. (LTN)

**4386** (UCRL-Trans—11132) **Cost benefits of underground gasification of brown coal with thermal preparation of the coal bed.** Shmakova, E.K. Translated from *Podzemn. Gazif. Uglei;* No. 4, 70-71(1958). 7p. Dep. NTIS $3.50.

When gasifying coal in accordance with the scheme for predominant gassing in the direction of the pillar and thermal preparation of the bed, the cost of 1,000 $m^3$ of gas is reduced by 3.4 to 4.7 rubles (9 to 12 percent) as opposed to its actual cost at the Podmoskovnaya Station. A greater reduction occurs in the case of strictly maintained thermal preparation of the coal (in the blocks of boreholes with thermally prepared coal). In connection with the increase in heating value of the gas, the cost of one megacalorie of the gas is reduced by 11 to 13 rubles, which amounts to 20 to 24 percent. This reduction in the gas cost increases the effectiveness of using it instead of coal by 25 to 30 percent.

**4387** (UCRL-Trans—11141) **Output rates of holes drilled in rows in an inhomogeneous seam, and the gas losses.** Semenenko, D.K. Translated from *Tr., Vses. Nauchno-Issled. Inst. Podzemn. Gazif. Uglei;* No. 3, 27-47(1960). 43p. Dep. NTIS $4.00.

On the basis of the calculations performed, the following conclusions can be drawn: (1) Analysis of the changes in the gas losses during the interaction of holes in an inhomogeneous seam shows that during UGC the gas losses may be reduced not only by reducing the pressure on the gas-removal holes but also by increasing the rate of blast injection for gasification to the maximum level possible. Another measure for reducing gas losses may be gasification with eduction of the gas in the direction of the gasified space, provided that the deposit is worked in the direction of the spread contour. (2) If the deposit is worked in the direction away from the spread contour, gasification with eduction of the gas toward the coal monolith may prove less effective than one with eduction of the gas toward the gasified space. (3) Artificial lowering of the permeability in the gasified zone in an effort to reduce the gas losses is undesirable. (4) Formation of the gasified zone and its subsequent broadening always reduce the gas losses, particularly when the deposit is gasified in the direction away from the spread contour and the gas is led toward the coal monolith. (5) Larger hole networks may give rise to a sharp increase in the gas losses only in the case when the deposit is worked away from the spread contour and the gas is led off into the coal monolith.

**4388** (UCRL-Trans—11143) **Underground losses of coal due to underground coal gasification.** Kazak, V.N.; Korolev, I.K.; Semenenko, D.K. Translated from *Tr., Vses. Nauchno-Issled. Inst. Podzemn. Gazif. Uglei;* No. 1, 69-71(1961). 6p. Dep. NTIS $3.50.

The underground losses of coal due to underground coal gasification depend mainly on the design of the underground gas producers, carbonization system, and mining-geological factors. In the Moscow Basin, among the structural characteristics of underground gas producers, those affecting the coal losses are the distances between the boreholes and the casing depth of the strings. Tests of various well patterns performed on the industrial gas producers of the Moscow Station showed the dependence of the coal losses on the dimensions of the borehole pattern.

**4389** (UCRL-Trans—11152) **New proposals concerning underground gasification of coal.** Yurchenko, V.P. Translated from *Tr., Vses. Nauchno-Issled. Inst. Podzemn. Gazif. Uglei;* No. 8, 115-117(1962). 6p. Dep. NTIS $3.50.

In order to attract a broad segment of the scientific and technical community to participation in efforts aimed at expanding the technology of underground gasification of coal, the Main Administration of the Gas Industry of the USSR and Academy of Sciences of the USSR conducted a competition for the best proposal for underground gasification of coal. The topics of the competition included: (a) methods and means for carrying out underground gasification of coal; (b) techniques of drilling directional holes through coal beds; (c) techniques of shaftless crosscutting; (d) techniques for automating the monitoring and control of the process of underground gasification of coal; and (e) techniques or systems for drying individual coal beds, and also deposits as a whole for purposes of their gasification.

**4390** (UCRL-Trans—11161) **Dependence of the UGC process on geological and hydrogeological conditions in hard coal deposits (discussion papers).** Korolev, I.V. Translated from *Tr., Vses. Nauchno-Issled. Inst. Podzemn. Gazif. Uglei;* No. 8, 51-58(1962). 16p. Dep. NTIS $3.50.

The geological situation in gasifiable deposits has an important influence on the underground gasification process (UGC process), and in the first place on its principal indicators: the calorific value of the gas and the degree of gasification of the coal. Hard coals are nowadays being gasified in the main coal basins of the USSR. The areas exploited by UGC are typical sections of geosynclinal deposits, the characteristic features of which are hard-rock roofs and floors of the seams and a complex tectonic structure. The basins also have their own specific aspects: thin coal seams are widespread in the Donbass, while thick seams predominate in the Kuzbass. Experience with the gasification of hard coal shows that the main natural factors affecting the UGC process are the lithological composition of the rocks containing the coal, the coal seam thickness, the presence of rock intercalations in the coal, the area's tectonics, and the presence of groundwater.

**4391** (UCRL-Trans—11151) **Nature of gas formation during counterflow crosscutting.** Fedorov, N.A. Translated from *Tr., Vses. Nauchno-Issled. Inst. Podzemn. Gazif. Uglei;* No. 7, 3-4(1962). 5p. Dep. NTIS $3.50.

Some anomalies of the gas composition resulting during the countercurrent air blast method of borehole linking are discussed. The interpretation is that they result from: the combustion of volatiles in the coal, the formation of water vapor, the adsorption of oxygen on coal or rocks, or some of the blast oxygen entering the fire channel beyond the combustion zone. (LTN)

**4392** (UCRL-Trans—11163) **Cost of the blast for underground gasification of coal.** Skafa, P.V. Translated from *Tr., Vses. Nauchno-Issled. Inst. Podzemn. Gazif. Uglei;* No. 10, 104-118(1963). 31p. Dep. NTIS $4.00.

The production of blast at underground stations for the gasification of coal seams is an important aspect of the technological UGC process. A table shows that the specific consumption of blast per unit thermal energy of the product gas (from practical data of underground stations' operation) is relatively high. Therefore, and also in view of the comparatively high energy requirements of blast production (55 to 65 kWh/1000 $m^3$), the cost of the blast is one of the principal components in the cost of the gas. In 1961 the cost of the blast in the works cost of the gas amounted to 52.7 percent at Podmoskovnaya station and to 25.0 percent at Yuzhnyi Abinsk station.

**4393** (UCRL-Trans—11133) **Experimental studies of the gas permeability of virgin coal beds in the Kiselevsk-Prokop'evsk region of the Kuznetsk Basin.** Kreinin, E.V.; Farberov, I.L. 1964. Translation of pp 184-187 from Gazifikatsiya i Piroliz Topliv, Nauka, Moscow, 1964. 8p. Dep. NTIS $3.50.

The gas permeability of coal beds has great significance both for the underground mining of coal deposits and for the underground gasification of coal beds. During underground mining of coal deposits, the methane contained in the coal beds is released into the underground workings, and there is danger of the formation of explosive mixtures of methane and air. The prediction of the amount of gas present in coal mines is acquiring especially great significance, for it makes it possible to determine the most efficient expenditures on shaft-type mines. The development of exact methods of predicting the amount of gas present in the mines requires that the laws determining the methane content of the coal beds and the country rock be known. The discovery of these laws has been the topic of many investigations.

**4394** (UCRL-Trans—11140) **Forward burning process and backward burning process in a model experiment on underground gasification of coal.** Ishikura, T.; Ebuchi, F. Translated from *Kyushu Daigaku Seisan Kagaku Kenkyusho Hokoku;* **39**: 8-19(1965). 30p. Dep. NTIS $4.00.

On the basis of gasification experiments in above ground channels it is concluded that (1) When the forward burning process is adopted, a high reaction temperature is obtained, and consequently it is possible to obtain gas of a high quality. (2) In the backward burning process, the volatile matter alone is burned, and the coke remains. Furthermore, the gas produced has a low quality because the reaction temperature is low. (3) The backward burning process has superior characteristics with regard to the continuity of combustion. Good results are anticipated if this characteristic is utilized in actual underground gasification to enlarge the channel, after which gasification could be performed aimed at the residue coke. In other words, it is believed that this process could be utilized as a secondary linking method. It is also believed that this coked portion could also be utilized in the process of gasification by the current dry distillation system. Various other results are reported, chiefly about the effect of process variables on the forward burning process.

**4395** (UCRL-Trans—11145) **Water balances of underground gasifiers.** Kalashnikov, P.I.; Khvoinskaya, R.S. Translated from *Tr. Inst. Proizvod. Opyt, Vses. Nauchno-Issled. Inst. Ispol'z. Gaza Nar. Khoz. Podzemn. Khraneniya Nefti, Nefteprod. Szhizhennykh Gazov;* No. 2, 97-110(1967). 27p. Dep. NTIS $4.00.

It has been established that under the conditions of underground coal gasification subterranean water both from the coal seam proper and from surrounding rock constantly participates in the formation of gas. In most cases the inflows of subterranean water into gasifiers reach significant values, thus adversely affecting the heat of combustion of the resultant gas. In connection with this, the water regime of underground gasifiers must be regulated in controlling the process of underground coal gasification. The water regime of underground gasifiers is determined by means of the water balances. Since the goal of water regime regulation is to increase the heat of combustion of the gas, the breakdown of the water balances should reflect the specifics of the influence of moisture content on the formation of gas produced by the underground gasification of coal. With this in mind, the principal types of water balances are presented.

**4396** **Effect of additives upon the gasification of coal in the synthane gasifier.** Forney, A.J.; Haynes, W.P.; Gasior, S.J.; Kenny, R.F. *Ann. Univ. M.Curie-Sklodowska, Sect. AA;* **19**: No. 1, 111-122(1974).

From 167. national meeting of American Chemical Society, Division of Fuel Chemistry; Los Angeles, CA, USA (1 Apr 1974).

Additives such as limestone, hydrated lime, and quicklime all have a positive effect on the gasification rate of coal. Limestone, in addition, raises the sintering temperatures and may lower the sulphur contained in the char from the gasifier.

**4397** **Development of alloys for the transfer of heat into fluidized coal beds with regard to steam gasification.** Kalwa, P.G. (Mannesmann-Forschungsinstitut G.m.b.H., Duisburg (F.R. Germany)); Van Heek, K.H. pp vp, Paper 42 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

A number of austenitic Cr-Ni-alloys with additions of Si, W, Mo, Ti, Nb and Co were tested in a fluidized bed of coal and steam at temperatures between 950 and 1050°C in a laboratory apparatus. The metallographic investigations demonstrate the influence of the alloying elements on the oxidation behaviour and give sufficient indications, that for this purpose a suitable material can be developed.

**4398** **Coal conversion and utilization R and D in ERDA.** Zahradnik, R.L. (Energy Res and Dev Adm). *Am. Gas Assoc., Oper. Sect., Proc.;* T8-T10(1975).

Programs in various power generation fields are discussed.

**4399** **Layout of an internally heated gas generator for the steam gasification of coal.** Feistel, P.P.; Duerrfeld, R.; van Heck, K.H.; Juentgen, H. (Bergbau-Forschung G.m.b.H., Essen (F.R. Germany)). *Nucl. Eng. Des.;* **34**: No. 1, 147-155(Oct 1975).

Industrial-scale steam gasification of coal using heat from high temperature reactors requires research and development on allothermal gas generators. Bergbau-Forschung GmbH, Essen, does theoretical and experimental work in this field. The experiments deal with reaction kinetics, heat transfer and material tests. Their significance for the layout of a full-scale gas generator is shown. Including material specifications, the feasibility of a gasifier, characterized by a fluid bed volume of 318 $m^3$ and a heat transferring area of 4000 $m^2$, results. The data, now available, are used to determine the gasification throughput from the heat balance, i.e. the equality of heat consumed and heat transferred. Throughputs of about 50 t/hr of coal are possible for a single gas generator, the helium outlet temperature of the HTR being 950°C/ Bergbau-Forschung has commissioned a medium-scale pilot plant (200 kg/hr).

### LIQUEFACTION

*REFER ALSO TO CITATION(S) 4398, 4635*

### PYROLYSIS AND CRACKING

**4400** (UCRL-Trans—11160) **Diffusion kinetic investigations of thermal degradation of coal in a bed.** Lisin, L.M.; Matasova, K.A. Translated from *Izv. Sib. Otd. Akad. Nauk SSSR, Ser. Khim. Nauk;* No. 1, 125-135(1963). 21p. Dep. NTIS $3.50.

An experimental study of the coal pyrolysis process by periods and stages for which unambiguous solutions of various equations are available, opens up the possibility of establishing, on the basis of the general principles underlying the process, partial principles that reveal the specifics of the properties of the coal and of the conditions of coal pyrolysis. The development and revision of these results of the investigation will on the one hand make it possible to work out engineering calculations of optimal technical solutions for the industrial use of coal pyrolysis processes, and on the other hand open up more effective ways of ascertaining the molecular structure of the organic matter in coal and the mechanism of coal pyrolysis, with a view to developing coking processes through studies of the composition of high-molecular-weight (tar) and low-molecular-weight (gas) products of pyrolysis.

## BY-PRODUCTS

*REFER ALSO TO CITATION(S) 5226*

**4401** **New developments in the USS PHOSAM process.** Hamilton, C.W. Jr.; Rice, R.D. (U.S. Steel Corp., Monroeville, PA). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

The commercial development of the USS PHOSAM Process for the recovery of coke-oven by-product ammonia in the form of high-purity anhydrous liquid ammonia is described. The process is gaining world-wide acceptance among coke producers, and applications outside the coke-plant field are anticipated.

## PROPERTIES

*REFER ALSO TO CITATION(S) 4371, 4375, 4390, 4394, 4439*

**4402** (BM-RI—8115) **Analyses of tipple and delivered samples of coal collected during fiscal year 1975.** Janus, J.B. (Bureau of Mines, Washington, D.C. (USA)). 1976. vp. Bureau of Mines, Washington, DC.

Analytical data of coal samples collected by the Bureau of Mines in connection with the purchase of several million tons of coal for various Government agencies during fiscal year 1975 are presented. Tipple samples were collected by Bureau of Mines engineers at tipples as coal was being loaded into railroad cars or trucks. Ultimate analyses are given for these coalbeds only.

**4403** (USGS-OFR—75-436, pp 29-35) **Variance analysis of the element composition of sweetclover and associated spoil materials from selected coal mines in the Northern Great Plains.** Erdman, J.A.; Ebens, R.J. 1975.

In Geochemical survey of the western coal regions. Second annual progress report, July 1975.

**4404** **Blast furnace coke quality: production versus tuyere coke.** Kinzer, W.K.; Kusner, R.E. (Republic Steel Research Center, Independence, OH). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

To obtain an insight into coke character, coke fed into the blast furnace and coke at the tuyere level were 1) sampled periodically at each of Republic Steel's six districts, 2) tested for physical properties and chemistry, and 3) characterized using the parameters of size consist, permeability, tumble test, coke reactivity, and alkali content. A comparison of the production and tuyere coke properties is then made. The results showed that the coke at the tuyere level was smaller in size consist, less permeable to airflow, weaker and more readily abradable, more reactive with carbon dioxide, and higher in alkali content than coke fed into the blast furnace.

## WASTE MANAGEMENT

*REFER ALSO TO CITATION(S) 5479*

**4405** **Comparison of flue gas desulfurization for eastern vs. western U.S. coals.** Sondreal, E.A.; Tufte, P.H. (Energy Research and Development Administration, Grand Forks, ND). *Trans. Soc. Min. Eng. AIME;* **258**: No. 2, 122-123(Jun 1975).

## ENVIRONMENTAL ASPECTS

*REFER ALSO TO CITATION(S) 4382, 5710*

**4406** (BM-IC—8695) **Coal surface mining reclamation costs: Appalachian and Midwestern coal supply districts.** Evans, R.J.; Bitler, J.R. (Bureau of Mines, Pittsburgh, Pa. (USA). Eastern Field Operation Center-Field and Environmental Activities). 1975. 54p. Bureau of Mines, Washington, DC.

Reclamation costs were estimated for 20 coal surface mining operations in the Appalachian and Midwestern Coal Supply Districts. The cost data were obtained through onsite observations, interviews with mining company personnel, and the authors' cost estimating procedures. The cost data are presented in terms of dollars per acre, dollars per ton of coal produced, and dollars per cubic yard of overburden moved during backfilling. The reclamation process is divided into three cost categories: Premining planning, backfilling, and revegetation. The average total reclamation costs for the three regions are $2.77 per ton of coal produced and $8,168 per acre. As the result of comparisons of reclamation costs by region, by mining method, by slope, and by size of operation, it was found that the most important reclamation cost difference is between area mining methods ($1.73 per ton) and contour mining methods ($3.81 per ton). This study was conducted to determine as accurately as possible the actual costs involved with the reclamation of surface-mined coal land in active mining operations.

**4407** (PB—242465) **State of the art of subsidence control. Final report.** Gray, R.E.; Gamble, J.C.; McLaren, R.J.; Rogers, D.J. (General Analytics, Inc., Monroeville, Pa. (USA); Pennsylvania Dept. of Environmental Resources, Harrisburg (USA)). Dec 1974. 273p. NTIS $8.50.

Prepared by General Analytics, Inc., Monroeville, Pa.

Methods of controlling or preventing surface subsidence damage above active and abandoned mines (particularly coal) are described. For abandoned mines, selective support methods, such as grout columns, deep foundations and piers; and filling methods, such as hydraulic flushing, pneumatic filling, fly ash injection, grouting, blasting and overexcavation are described and approximate costs presented. Techniques to evaluate subsidence potential are included. For active mines, principles of subsidence development above tabular deposits are discussed, including a review of research studies and predictive methods. Subsidence control, by cancelling or selectively positioning surface strains, and subsidence prevention by subsurface support are described with examples. Annotated bibliographies are included. (GRA)

**4408** (USGS-OFR—75-436) **Geochemical survey of the western coal regions. Second annual progress report, July 1975.** (Geological Survey, Denver, Colo. (USA)). 1975. 133p. TIC.

Three relevant papers from the second annual progress report describing current work in a broad-sealed reconnaisance geochemical study of landscape materials in the major coal-bearing regions of the western United States have been entered into ERA and EDB. Nine other papers discuss the chemical composition of rocks, ground water, plants, etc., and methods of analysis and sampling. (LTN)

**4409** (USGS-OFR—75-436, pp 82-128) **Miscellaneous geochemical data on Late Cretaceous and early Tertiary fine-grained sedimentary rocks from the western coal regions.** Mendes, R.V.; Van Trump, G. Jr. 1975.

In Geochemical survey of the western coal regions. Second annual progress report, July 1975.

The bulk of the western coal currently being mined or subject to mining in the near future is of Late Cretaceous or early Tertiary age. In general, it occurs above the broad expanse of carbonaceous gray marine shales and below less well bedded, generally variegated rocks of fluviatile aspect, commonly referred to as the Wasatch Formation of Eocene age or its lithic equivalents. Development of these coal resources, particularly by surface mining, will result in drastic changes in the local landscape. One of the more important of these changes could be the "substitution" of the natural soil cover with an unnatural cover composed in part of a mixed accumulation of those rocks associated with or lying above strippable coal layers. Miscellaneous chemical analyses of a large number of such rocks already analyzed in laboratories of the U.S. Geological Survey are listed.

**4410** **Clearing the way for coal.** Train, R.E. pp 1-7 of In First symposium on coal management techniques. Volume II. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P2.

## RESERVES AND EXPLORATION

*REFER ALSO TO CITATION(S) 4403, 5183*

## MINING

*REFER ALSO TO CITATION(S) 4387, 4393, 4409*

**4411** (BM-IC—8617) **Bureau of Mines direct-reading azimuth protractor.** Bolstad, D.D.; Mahtab, M.A. (Bureau of Mines, Washington, D.C. (USA)). 1974. 7p. Bureau of Mines, Washington, DC.

The construction and use of a direct-reading azimuth protractor (DRAP) for measuring fracture orientations in mines, tunnels or other excavations having a magnetic environment are described.

**4412** (BM-RI—7907) **Mine roof reinforcement by specifically designed epoxy resin systems.** Subramanian, R.V.; Austin, H.; Raff, R.A.V.; Franklin, J.C. (Bureau of Mines, Spokane, Wash. (USA). Spokane Mining Research Center). 1974. 17p. Bureau of Mines, Washington, DC.

The use of polymers to achieve rock bonding and reinforce coal mine structures for better or permanent ground support was investigated. Support was achieved by pumping the polymers into the rock interstices to bond the mass together for increased structural competence. Holes were drilled in the mine roof, after which the polymers were injected at about 100 psi to permeate the cracks. Initial laboratory work indicated that of all the resin systems tested, the epoxy resins could most likely be modified to be suitable for rock injection. This was confirmed when several potentially suitable resin systems underwent intensive evaluation. Rock bonding as done by injection of self-hardening liquids is capable of simultaneously consolidating, stabilizing, and strengthening roof structures by bonding thin weak strata, and of preventing vertical detachment as well as lateral sliding. This method can also be combined with the usual technique of reinforcement by roof bolting. It is obvious that a combination of both methods of reinforcement, namely, rock bonding and roof bolting, will weld the mine roof into one beam, forming a single, solid pressure arch capable of transferring its load to the sides of the opening with minimum danger of caving. This simultaneous application of both methods can be expected to achieve a higher degree of safety than either method used alone.

**4413** (BM-RI—8112) **Geologic and ground-control aspects of an experimental shortwall operation in the upper Ohio Valley.** Moebs, N.N.; Curth, E.A. (Bureau of Mines, Pittsburgh, Pa. (USA). Pittsburgh Mining and Safety Research Center). 1976. vp. Bureau of Mines, Washington, DC.

Valley Camp No. 3 mine was the scene of an experimental shortwall introduced in 1973 in an attempt to improve the recovery from the Pittsburgh coalbed in the Ohio Valley area where adverse ground conditions have imposed partial extraction methods with only 40 to 55% recovery of the valuable resource. The Bureau of Mines, under a cooperative agreement with Valley Camp Coal Co., monitored ground pressures and caving in the shortwall section in an effort to determine whether the roof strata, notably the limestone main roof, will cave to the extent that roof pressures at the face are relieved and whether the powered roof supports can sustain the roof load. The Bureau's efforts included mapping of clay veins, instrumentation of chain pillars and shortwall panels with encapsulated pressure cells, recording hydraulic pressures in the legs of the shortwall chocks, and core drilling underground and from the surface. The experimental shortwall was a qualified success. Recovery increased 5.4% compared with partial extraction. Pressures in chain pillars and the abutment zone were not excessive. Hydraulic pressures in the chock legs did not approach the yielding pressure. Apparently, the limestone strata caved and the roof pressure at the face was relieved.

**4414** (BM-RI—8117) **Methane gas content of the Mary Lee group of coalbeds, Jefferson, Tuscaloosa, and Walker Counties, Ala.** Diamond, W.P.; Murrie, G.W.; McCulloch, C.M. (Bureau of Mines, Pittsburgh, Pa. (USA). Pittsburgh Mining and Safety Research Center). 1976. vp. Bureau of Mines, Washington, DC.

It is estimated that more than 1 trillion cubic feet of methane is contained within the coals of the Mary Lee group in Jefferson, eastern Tuscaloosa, and southern Walker Counties, Ala. Most of this methane will be encountered by mining. Coals of the Mary Lee group are presently being mined at depths exceeding

1,000 ft and will in the near future be mined at even greater depths, where the problem of methane gas affecting the mining operations will be acute. It is calculated that approximately 90% of the methane is at depths greater than 1,000 ft, and over half of the gas is contained within only 12% of the study area which is under more than 1,500 ft of overburden. Degasification in advance of mining will increase mine safety, reduce ventilation expenditures, increase productivity, provide an additional energy source, and make it possible to mine parts of deep coalbeds that probably could not otherwise be mined.

**4415** (PB—241785) **Coal manpower projections, 1980. Final report.** Clague, E. (Kramer Associates, Inc., Washington, D.C. (USA)). 27 Sep 1974. Contract DL-20-11-74-17. 68p. NTIS $4.25.

Bituminous coal production of 910 million tons in 1980 was projected by the National Petroleum Council in their report on U.S. Energy Outlook, 1971-85. On that foundation this manpower study estimates the manpower which would be required to produce that volume of coal output. Productivity of labor in coal mining declined about 30 percent during 1970-73 under the impact of higher safety and health standards established by congressional legislation. On the assumption of a productivity increase of 2 percent per year from 1974 onwards, the 1980 coal output would require a work force of about 200,000 workers, about 45,000 above 1973 employment. Additional workers needed to replace those who die or retire would raise new manpower requirements to about 15,000 men a year for the remainder of the decade. The most critical requirement will be for highly skilled workers, such as mining machine operators, roof bolters, and others, who will be needed to man the increasing mechanization of coal production. There will be urgent need of training programs for young miners, both in work safety and in mining skills. (GRA)

**4416** (UCRL-Trans—11138) **Maximum possible drainage of coal-overlying water-bearing sand in flat-pitched seams.** Troyanskii, S.V.; Troyanskii, V.S.; Fisenko, N.E. Translated from *Podzemn. Gazif. Uglei;* No. 4, 64-66(1958). 10p. Dep. NTIS $3.50.

It has been proposed to build a number of experimental gasifiers, and subsequently industrial gasifiers, in the flooded deposits of the Podmoskovnyi and Dneprovskii Lignite Basins. Here the subterranean waters form coal-overlying aquiferous horizons in the upper part of a profile view, and a coal-underlying horizon in the lower part. Fine sand serves as the surrounding medium for the first coal-overlying horizon. Coal-underlying water is observed in the Moscow Coal Basin in a layer of sand below which is limestone, while in the Dneprovskii Basin the water is found in a thick layer of sand. The coal-underlying water usually is pressure water. Preliminary drainage from the surface by means of boreholes and by pumping water from them with borehole pumps is used to reduce the bottom-water head during underground coal mining in deposits of the Moscow Coal Basin.

**4417 Winning coal: a report on a technology assessment of coal extraction by underground mining methods.** Schmidt, R.A. (Electric Power Research Inst., Palo Alto, CA). pp 29-49 of In First symposium on coal management techniques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

The Electric Power Research Institute (EPRI) is undertaking a program of research in coal extraction, preparation, and utilization on behalf of the electric utility industry. As part of this program, EPRI seeks to provide comprehensive, authoritative, and responsible description of extraction-related technologies together with the consequences of their application upon industry, society, and the physical environment. In keeping with EPRI's role as a catalyst to inspire further effort or to focus attention on matters of particular importance, such fundamental information can be invaluable to guide advance planning of specific research and development activities, as well as to provide valuable support to those who formulate energy policy. Coal is of concern to this program because it represents a major source of energy to the electric utility industry. In order to finalize EPRI's plans for R and D aimed at problems in the future coal development, thorough appraisals of coal extraction and preparation processes are required to place in perspective the opportunities and constraints upon utilization of this important energy resource. There is a clear need for better understanding of technologies and practices for deep mining of coal, as well as for preparation of the mined product for use. Accordingly, EPRI has sponsored this multidisciplinary study. A companion study of coal preparation is in progress. A competitive procurement process was employed in each case in which proposals were solicited from several firms and were evaluated according to a comprehensive set of criteria by a specially-assembled group of experts. For this study of underground coal mining, the reviewers selected a team assembled by Hittman Associates, Inc., as prime contractor, and includes Pennsylvania State Univ. and George Washington Univ. This paper presents a brief overview of the study and its principal conclusions. (auth)

**4418 Motivational factors in accepting the supervisory position.** Smith, F.J. (Smith Associates, Chicago); Smith, B.B.; Standing, T.E. pp 51-60 of In First symposium on coal management techniques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

**4419 Socio-technical design and its effect on individual and group performance.** Brown, G.R.; Susman, G.; Trist, E. (Pennsylvania State Univ., University Park). pp 61-70 of In First symposium on coal management techniques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

Work, what work is, and what it should be, a philosophy of management called socio-technical systems, and a research project at Rushton Mining Company are discussed. The aim was to develop professional miners competent in all the tasks required on a mine section and therefore able to deploy themselves flexibly and to regulate their work in relation to each other. Progress in this project and its effects on employee thinking and productivity are discussed. (MCG)

**4420 Absentee control program.** Cathcart, J.T.; Snow, T.B. (Eastern Gas and Fuel Associates, Boston). pp 71-79 of In First symposium on coal management techniques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

**4421 Operation of a pilot new-miner orientation program.** Saperstein, L.W.; Brown, G.R.; Anderson, R.B. (Pennsylvania State Univ., University Park). pp 81-93 of In First symposium on coal management techniques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

In response to impending regulations from the Commonwealth of Pennsylvania and the Federal Mining Enforcement and Safety Administration, and the subsequent bituminous wage agreement, the mining section of The Pennsylvania State University applied for a grant to perform a pilot new-miner pre-employment orientation program. With the concurrence of the Governor's Energy Council and his Manpower Services Council, a CETA grant was arranged. Program details were suggested by Penn State and approved by the Bureau of Deep Mine Safety, Pennsylvania DER and the UMWA. The curriculum extends over a five-day period and includes an introduction to mining, first-aid, personal safety equipment, gas and dust protection, analysis of safety, a mine trip and several other topics. As many as five concurrent classes with 20 people per class are being held in locations convenient to the mines. Curricular and organizational details are given in the paper. The program should give instruction to up to 2,000 men and should lay the groundwork for company-sponsored programs. (auth)

**4422 Mining extension service: a systematic, extension education approach to coal miner training.** Letcher, D.A.; Gerkin, J.P. (West Virginia Univ., Morgantown). pp 95-103 of In First symposium on coal management techniques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

**4423 National Mine Health and Safety Academy.** Zabetakis, M.G. (Mining Enforcement and Safety Administration, Arlington, VA). pp 105-110 of In First symposium on coal management

technjques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

The present series of training programs was developed following passage of PL 89-577 (Federal Coal Mine Health and Safety Act) in December 1969. A number of programs were developed to train mine inspectors, and to date over 1000 have been trained. Courses have been given in accident prevention, industrial hygiene, roof control, gas detection, fire protection, ventilation, electricity, permissibility, transportation and haulage, hoisting, inspection procedures, explosives and blasting, and the law. (MCG)

**4424 Management development, a key to success in the coal industry.** Ahmed, B.G. (Mining and Land Development Services, Inc., Wheeling, WV). pp 111-119 of In First symposium on coal management techniques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

**4425 Activities of the Division of Coal Mine Workers's compensation.** Miller, F.E. (Dept. of Labor, Washington, DC). pp 121-133 of In First symposium on coal management techniques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

The provisions of the law for the payment of compensation to miners disabled by black lung disease are discussed. Four appendixes are included: (A) Comparison of Benefit Provisions Under Parts B and C of Title IV, Federal Coal Mine Health and Safety Act of 1969, as Amended; (B) Regulations Issued; (C) Percent of Claims Filed by State, July 1975; and (D) Summary of Coal Mine States' Black Lung Legislation, 1970-1974. (EJH)

**4426 Can wildcat strikes be tamed.** Hobgood, W.P. (Federal Mediation and Conciliation Service, Washington, DC). pp 134-139 of In First symposium on coal management techniques. Volume I. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P1.

**4427 Banquet address.** Frizzell, K. (Dept. of the Interior, Washington, DC). pp 9-12 of In First symposium on coal management techniques. Volume II. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P2.

Coal and its critical place in the Nation's energy picture are discussed. (MCG)

**4428 National Bituminous Coal Wage Agreement of 1974: a review of problems and possible solutions.** Brennan, J.P. (Bituminous Coal Operators's Association, Inc., Washington, DC); Pack, A.S. pp 13-19 of In First symposium on coal management techniques. Volume II. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P2.

The authors point out that despite the 1974 agreement, which by consensus is among the best in the nation, the coal mining industry is still plagued by wildcat strikes, labor-management confrontations, and extensive litigation seeking to insure contract compliance. The seriousness of the situation is partially shown in the statistics of man-days lost to wildcat strikes: 593,000 in 1970, slightly less for the next 3 years, but 1,006,000 in 1974 and 1,368,000 in the first 8 months of 1975. The new importance of coal suggests that a vital objective of labor relations must be a strike-free operation during the term of any national wage agreement; some suggestions are presented on how to accomplish this most difficult objective. (LMT)

**4429 One company's experience with productivity.** Meador, H.W. Jr. (Westmoreland Coal Co., Big Stone Gap, VA). pp 33-34 of In First symposium on coal management techniques. Volume II. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P2.

**4430 Joint union-management training efforts under the 1974 Wage Agreement.** Lohr, R.J. (Bituminous Coal Operator's Association, Inc., Washington, DC). pp 39-45 of In First symposium on coal management techniques. Volume II. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P2.

Mr. Lohr is a member of the Joint Industry Training Committee, which was created under Article XVI of the National Bituminous Coal Wage Agreement of 1974. He points out that, in preparation for the 1974 negotiations, the United Mine Workers made it very clear that they would be demanding increased emphasis on safety and skill training. The industry agreed, at least in principle, and the difficulty in reaching agreement was not over need for training but rather the degree to which the industry could reasonably be expected to implement the training; in other words, how many training programs could be implemented within a given time frame, and what would a sudden increase in training do to operations. When the committee met for the first time in April 1975, the following programs of Article XVI (each discussed briefly) were already in the process of being implemented: (1) Orientation of New Employees; (2) General Retraining Programs; (3) Safety Training for a Specific Job; (4) Maintenance Training and Rate of Pay; (5) New Inexperienced Employees at Underground Mines; and (6) General Training Provisions. (LMT)

**4431 Mining boom linkage for separate sump and swing cutting.** Dolecki, M.J. (to Joy Manufacturing Co.). US Patent 3,966,258. 29 Jun 1976. Filed date 16 Dec 1974. 6p.

An underground mining apparatus having a disintegrating head portion carried by an improved pivotal linkage arrangement is described.

**4432 Driving arrangement for rotary mining heads of mining machines.** Shah, A.K. (to Lee-Norse Co.). US Patent 3,966,257. 29 Jun 1976. Filed date 26 Aug 1974. 8p.

A mining machine of the type wherein the rotary mining head comprises at least one rotatable support carrying a plurality of cutter drums. The support is rotatably driven through a gear box including gearing connected to the support by a plurality of drive shafts thereby providing the mining head with substantially increased power and torque, for the employed diameter of drive shaft, while also providing other described advantages. Each of the drive shafts is connected to the gearing through a clutch whereby the load is divided between the drive shafts and the shafts are automatically disconnected from the gearing in the event that the mining head encounters high resistance to its driven rotation.

**4433 How computerized instrumentation monitors coal mine roofs.** McVey, J.R.; Serbousek, M.O. (Bureau of Mines, Spokane). *Min. Eng. (N.Y.)*; **28**: No. 9, 40-43(Sep 1976).

Determining and evaluating an underground opening during actual production is a real challenge. Instruments must be installed as the mining cycle progresses in order to obtain a realistic profile (of load, load rates, deformation rates, supporting rock strength, and closure) that can best represent the opening while the face advances. In the coalbeds sampled by USBM, all instruments had to be installed during each bolting operation. USBM chose a computerized instrumentation system that would allow: Computing rates on-site and knowing exactly what the opening was doing as the face advanced; instantaneous computing and plotting of other pertinent data on-site; automatic real time access to any instrument any time from outside the mine without going underground; up-to-date information at any time throughout the mining cycle; and programming load and other limits. With the computer continuously monitoring the instruments, warnings can be given, equipment can be shut down, or the entire mining operation can be stopped when these limits are reached. Other measurements, including methane, ventilation, and conveyor loads, can be made and monitored for optimum mine production.

## TRANSPORT AND HANDLING

*REFER ALSO TO CITATION(S) 4442, 5227*

**4434** (BM-RI—7832) **Undulatory conveyor tests and evaluation.** Kleysteuber, W.K.; Miscoe, A.J. (Bureau of Mines, Pittsburgh, Pa. (USA). Pittsburgh Mining and Safety Research Center). 1974. 16p. Bureau of Mines, Washington, DC.

The design and testing of a novel bulk materials conveying device is reported. The transport concept of the device is to create a traveling wave with a steep front so that the bulk material slides and cascades down the front of the wave with some horizontal motion. Ideally, the front should act like a continuous chute. The concept of moving bulk materials along a belt without any forward movement of the belt itself was demonstrated. The conclusions reached were that the mechanism as designed could not overcome the inherent major disadvantages required to make the undulatory conveyor suitable for practical applications. The disadvantages are listed.

**4435** **Pipeline charging preheated coal to coke ovens.** Davis, R.F. Jr.; Cekela, V.W. Jr. (Allied Chemical Corp., Ironton, OH). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

The Coaltek system has demonstrated at various operating installations that it provides a practical solution to many of the current problems that are facing coke producers, including a means of eliminating conventional charging emissions, providing improved working conditions, and permitting the use of inferior quality coals.

## COMBUSTION

*REFER ALSO TO CITATION(S) 4372, 4383, 4402, 5317*

**4436** (PB—241821) **Identification and characterization of the use of mixed conventional and waste fuels. Environmental protection technology series (final).** Mathur, G.K. (Kellogg (M.W.) Co., Houston, Tex. (USA)). Feb 1975. Contract EPA-68-02-1308. 65p. NTIS $4.25.

The major objective of this study was to identify and classify types and properties of mixed fuels presently in use, and types of stationary processes using mixed fuels. Types of mixed fuels include mixed oils; oil and gas; coal and oil; coal and gas; by-product gases and fuels; by-product chemical waste; and mixtures of chemical wastes and conventional fossil fuels. The scope of the task covered industries in the category of Utilities, Petroleum Refineries, Petrochemical, Chemical Processing (excluding fertilizer), Glass, Cement and Textile. A list of manufacturers of mixed fuel burners was developed. (GRA)

**4437** **Direct reduction of iron ores: processes and products.** Elliott, J.F. (MIT, Cambridge, MA). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

The general nature of processes for producing direct reduced iron (DRI) is discussed. Particular emphasis is placed on the type of fuel that is used in the processes. The effects of gangue content and degree of reduction of the DRI on the energy requirement for steelmaking and on the nature of electric furnace operations are considered.

**4438** **Practical aspects of coal firing in the induration of iron ore pellets.** Frommer, D.W.; Nigro, J.C. (Twin Cities Metallurgy Research Center, U.S. Dept. of the Interior, MN). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

Various aspects of the energy crisis as it affects iron ore pelletization are discussed. Supply, characteristics, and costs of gas, oil, and coal are examined and show that coal is likely to be the most available of the optional fuels and at lower costs. Several alternative methods of utilizing coal in the various pelletizing furnaces are examined, and experimental data illustrating one application to a grate-kiln-type pelletizing unit are presented. These experimental data were obtained in the Bureau of Mines Twin Cities Metallurgy Research Center pilot plant, using pellets prepared from commercial taconite concentrates. Four tests were made comparing firing of natural gas with three coal samples, a Kentucky bituminous, a Colorado bituminous, and a Montana subbituminous coal. Pellet contamination by coal ash was not deemed to be substantial. Kiln ringing, related in part to ash fusion temperature, was a serious problem with the Colorado coal, negligible with natural gas and the Kentucky coal, and of moderate severity with the Montana coal.

**4439** **Future trends in blast furnace fuels.** Ostrowski, E.J. (National Steel Corp., Weirton, WV). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

Future blast furnace fuels will be coal based. Available data support the fact that coke rates could increase due to the lower quality of coal and the decrease in the availability of good quality injectants. Injection of pulverized coal could offset the losses in injectants such as natural gas and fuel oil. The role of formcoke in future demands is very important because it minimizes the dependence on low volatile coal. Decreasing the amount of low volatile coal in the coal mix used to produce slot oven coke results in lower coke physical qualities which are essential to high blast furnace performance. Some of these qualitites can be regained by utilizing the hot coal charging process; therefore, hot coal charging could play a key role in fuel availability. Nuclear energy should not have an impact on fuel demands in ironmaking. 11 refs.

**4440** **Corrosion and deposits from combustion of solid waste. IV. Combined firing of refuse and coal.** Krause, H.H.; Vaughan, D.A.; Boyd, W.K. (Battelle Columbus Labs., OH). *J. Eng. Power;* **98**: No. 3, 369-374(Jul 1976).

From ASME Winter annual meeting; Houston, TX, USA (30 Nov 1975).

Combined firing of processed municipal refuse with coal has been investigated in a stoker-fired boiler. The refuse preparation consisted of shredding, magnetic separation of metals, and air classification. The nature of the deposits and the extent of corrosion of simulated boiler tube surfaces was determined by inserting probes into the boiler. For amounts of refuse up to 35 percent on a heating value basis, the corrosion rate of carbon steels was reduced substantially below that found from previous measurements for refuse alone, and below that calculated on the basis of dilution by the coal. The temperature of the boiler flue gases also was found to be an important factor in corrosion. The emissions of sulfur oxides from high sulfur coal were reduced by the action of the alkaline components of the refuse.

## MARKETING AND ECONOMICS

*REFER ALSO TO CITATION(S) 4428*

**4441** **First symposium on coal management techniques. Volume II. NCA/BCR coal conference and expo II, Louisville, Kentucky, October 21—23, 1975.** Washington, DC; National Coal Association (1975). 48p. (CONF-751090—P2).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

This volume contains the keynote address by Russell E. Train, U.S. Environmental Protection Agency, and a banquet address by Kent Frizzell, U.S. Dept. of the Interior. In addition, six other papers are included, with three abstracted for Energy Abstracts for Policy Analysis (EAPA). All of the eight papers are announced in ERDA Energy Research Abstracts (ERA).

**4442** **Marketing and transporting coal.** Huegel, L.J. (Consolidation Coal Co., Pittsburgh). pp 21-27 of In First symposium on coal management techniques. Volume II. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P2.

Mr. Huegel points out that while the various markets for coal—electric power, metallurgical uses, industrial uses, and conversion—should grow (in varying degrees), there are some imponderables under the general heading of "constraints" that the coal industry must overcome to satisfy these markets. Among these constraints are labor instability, Federal legislation, declining productivity, investment capital, and transport; all of these are elaborated to some extent. In addressing the problems of transport, Mr. Huegel doubts that slurry pipelines will be a factor during the next ten years. He sees expansion capital and greatly improved transportation as the two paramount needs. (LMT)

**4443** **Personnel management: from work to quality of worklife.** Warren, A.S. Jr. (General Motors Corp., Detroit). pp 35-38 of In First symposium on coal management techniques. Volume II. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P2.

## HEALTH AND SAFETY

*REFER ALSO TO CITATION(S) 4412, 4425, 4433*

**4444 Setting up and administering a black lung fund.** Correll, L.B. (Westmoreland Coal Co., Philadelphia). pp 29-31 of In First symposium on coal management techniques. Volume II. Washington, DC; National Coal Association (1975).

From 1. symposium on coal management techniques; Louisville, Kentucky, United States of America (USA) (21 Oct 1975).

See CONF-751090—P2.

## REGULATIONS

**4445** (AEC-tr—7533/9, pp 47-57) **Use of stable tracers in chelate compounds and of neutron activation for investigation of water filtration in mines.** Jureczko, J. (Central Mining Inst., Katowice, Poland); Dulewski, J.; Zmij, M.; Adamski, L.; Jozefowicz, K. Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

Use of the stable tracer method and of the neutron activation analysis for examination of water filtration in coal mines is discussed. The chromium ion combined in a chelate complex with EDTA was used as tracer. A special preparation of samples allowed to increase considerably the degree of tracer detectability. The sensitivity attained was 2.5 x $10^{-10}$ g/ml. The first part of the paper covers the survey of tracer methods used for investigation of water filtration, next parts-methods for preparation of the chelate tracer, preparation of samples of water containing the tracer, activation of samples in the reactor and spectrometric measurements. On the basis of tests carried out the ways of flow of washery waters delivered to workings left after the extraction of coal were determined. In addition the percentage of the delivered water which remains in the rock strata was determined.

# PETROLEUM

*REFER ALSO TO CITATION(S) 4368, 4369*

**4446** (PB—242751) **Petroleum industry: a report on corporate and industry structure and ownership. Part 1.** Iannone, J.M. (Shriver (R.) Associates, Parsippany, N.J. (USA)). 25 Apr 1975. Contract FEA-C-03-50035-00. 405p. NTIS $10.50.

This report lists some 1500 parent petroleum companies and over 8000 domestic and foreign subsidiaries, affiliates, and investments in refining, marketing, production, pipelines, uranium, geothermal, coal, and non-energt areas. It provides the equity share owned by the parent firms and identifies the principal business for each subsidiary, affiliate, and investment. For joint ventures in crude production and refining, it presents the parent's equity interest, plus a list of joint-venture partners and their investments. The basic list of oil companies and affiliates was verified, updated and expanded by the oil companies themselves--providing data for a substantial number of subsidiaries and affiliates not previously available. (GRA)

## EXPLORATION

*REFER ALSO TO CITATION(S) 5634*

**4447** (GKSS—76/E/29) **Preliminary investigations of the overturning stability of the research platform Nordsee.** Relotius, P.; Schellin, T.E.; Witte, G. (Gesellschaft fuer Kernenergieverwertung in Schiffbau und Schiffahrt m.b.H., Geesthacht-Tesperhude (Germany, F.R.)). 1976. 7p. (In German). Dep. NTIS (US Sales Only) $3.50.

Using strain gauges wave loads were measured on one corner section of the research platform "Nordsee." The measured results were correlated with the corresponding sea states in order to determine the experimental response operators of the horizontal forces and the overturning moments. Computer calculations were carried out to determine the respective theoretical response operators. The agreement is good between the experimental and the theoretical response operators within a range of periods near the significant period of the measured sea states.

**4448** (GKSS—76/E/30) **Dynamic response analysis for the research platform Nordsee by periodic excitation.** Longree, W.D.; Kolb, M.; Payer, H.G. (Gesellschaft fuer Kernenergieverwertung in Schiffbau und Schiffahrt m.b.H., Geesthacht-Tesperhude (Germany, F.R.)). 1976. 15p. (In German). Dep. NTIS (US Sales Only) $3.50.

The design of the Research Platform Nordsee reflects static as well as dynamic considerations. To test the vibrational analysis the structure was agitated using a mechanical exciter in frequencies of up to 18 Hz. The structural behaviour was measured and recorded. This paper illustrates experimental aspects and results. Two methods of response analysis are described and a comparison of the calculated values with experimental results is presented.

**4449 Exploration methods for small operator offered.** Armstrong, F.E. (Energy Research and Development Administration, Bartlesville, OK); Quigley, M.D. *Oil Gas J.;* **74**: No. 20, 264-267, 270(17 May 1976).

Cost factors in the use of modern geophysical exploration methods by small operators and the difficulty in interpreting the data obtained led to a research project to develop and evaluate a rapid, economical exploration system suitable for use by the small operator. The results obtained are illustrated by reporting a survey made in the Van Horn-Long Creek area of Kansas in which radiometric, magnetic, and gravity methods were used. The survey techniques and data interpretation are discussed. The survey indicated two strong and three relatively attractive prospects for exploration drilling with less than half of the township covered by the surveys. (JSR)

## DRILLING AND PRODUCTION

**4450** (BM-RI—8121) **Waterflooding of oilfields in Montana.** Biggs, P. (Bureau of Mines, Denver, Colo. (USA). Intermountain Field Operation Center). 1976. vp. Bureau of Mines, Washington, DC.

This report presents information on 77 waterflood projects in 31 Montana oilfields. The study shows the locations of the projects, the sources and amounts of injection water, and the results in oil produced. Waterflooding, a secondary recovery technique, began in Montana about 40 years after the initial oil discovery in 1920. Often, the difference between water disposal by injection and pressure maintenance operations is not clear. Water injected at the projects in 1973 was 157.7 million barrels. In 1973, the 31 fields having waterflood projects produced 28.3 million barrels of oil valued at $88.4 million. Both in volume and value, this represents over 80 percent of the State's 1973 oil output. The projects are making possible the recovery of additional oil, thus contributing to the conservation of oil and lessening the impact of the current oil shortage.

**4451** (PB—243347/2ST) **Assessment of enhanced recovery technology as a means for increasing total crude oil recovery in Texas. Final report.** Lohse, E.A. (Texas Governor's Energy Advisory Council, Austin (USA)). 6 Jan 1975. 78p. NTIS $4.75.

Also published as Gulf Universities Research Consortium, Galveston, Tex., GURC-141.

Enhanced recovery (ER) refers to chemical and/or thermal treatment of oil reservoirs to increase the production of crude oil beyond those amounts recoverable by natural reservoir energy (primary recovery, by water drive or gas pressure) or by artificial maintenance of reservoir energy (secondary recovery by waterflood or gas injection). Current ER methods consist of (1) polymers to thicken reservoir water for more uniform sweep of water through the reservoir, (2) miscible fluids to reduce interfacial tension between the reservoir rock's very small pore spaces and the oil, or (3) heat applied in some form such as steam or underground combustion. Detailed analyses of 242 Texas oil fields as a representative sample of the Texas oil resource are presented. (GRA)

**4452 New casing inspection log.** Cuthbert, J.F.; Johnson, W.M. Jr. (Schlumberger Well Service, TX). *Am. Gas Assoc., Oper. Sect., Proc.;* T209-T217(1975).

The new Pipe Analysis Log employs separate tests of the total casing wall and of the inner surface. Together, these two measurements permit detection, with a high degree of resolution, of small defects and corroded areas in the pipe, and also provide the ability to discriminate between defects on the inner and outer walls of a single string of casing. Example logs of the new casing-inspection tool, selected from an extensive test program and nine months of commercial application, are presented. Comparisons are

made of the results from the new tool with defects observed in the pipe when out of the well. Data are shown graphically and tabularly. 5 refs.

**4453 Demand for oil-recovery chemicals is estimated.** Crump, R. *Oil Gas J.*; 74: No. 20, 158-162(17 May 1976).

An article based on an ERDA-sponsored study of the demand and availability of chemicals used in microemulsion flooding is presented. Demand factors for petroleum sulfonates, alcohol, and polymers and factors affecting these demands are summarized. The current production of these chemicals is not adequate to meet either of the three cases of microemulsion flooding considered. Uncertainties in the extent of microemulsion flooding and the type of alcohol to be used, and the dissatisfaction with the current generation of polymers make it difficult for management to initiate increased production facilities for any of the chemicals. (JSR)

## PROCESSING

*REFER ALSO TO CITATION(S) 4645*

## PRODUCTS AND BY-PRODUCTS

*REFER ALSO TO CITATION(S) 4642, 4644, 4646*

## MARKETING AND ECONOMICS

**4454 Why temperature correction.** Mattimoe, G.E. (Dep of Agric, State of Hawaii). *Natl. Bur. Stand. (U.S.), Spec. Publ.*; No. 407, 166-181(Jun 1975).

Calibration adjustments are discussed and presented in graphical form.

**4455 Report of the committee on specifications and tolerances.** Brink, T.R. (Dep of Agric, State of Vt). *Natl. Bur. Stand. (U.S.), Spec. Publ.*; No. 407, 228-242(Jun 1975).

Codes and amendments are reported for various devices.

## WASTE MANAGEMENT

**4456 (PB—242461) Preliminary design of a comprehensive waste oil processing facility. Final report.** Gumtz, G.D.; Martin, E.J. (Maryland Environmental Service, Annapolis (USA); Environmental Quality Systems, Inc., Rockville, Md. (USA)). May 1975. 142p. NTIS $5.75.

Prepared in cooperation with Environmental Quality Systems, Inc., Rockville, Md.

A preliminary design is presented for a comprehensive waste oil recovery and disposal facility for the State of Maryland. The base for this design was an annual state-wide waste oil generation of 22,000,000 gallons which includes all known waste oil sources. With a 90 percent stream factor, feed to the plant is 66,000 gallons per day. (GRA)

## ENVIRONMENTAL ASPECTS

*REFER ALSO TO CITATION(S) 5228, 5229, 5653, 5759*

**4457 (N—75-20799) Remote sensing applied to crop disease control, urban planning, and monitoring aquatic plants, oil spills, rangelands, and soil moisture. Program summary progress report, 1 Aug 1974—1 Feb 1975.** (Texas Agricultural and Mechanical Univ., College Station (USA). Remote Sensing Center). 1 Feb 1975. Contract NGL-44-001-001. 70p. (NASA-CR—142558; RSC—08). NTIS $4.25.

The application of remote sensing techniques to land management, urban planning, agriculture, oceanography, and environmental monitoring is discussed. The results of various projects are presented along with cost effective considerations. (GRA)

**4458 (N—75-24122) Interdisciplinary study of atmospheric processes and constituents of the mid-Atlantic coastal region. Attachment 4. Data set for background investigation of atmospheric constituents for Nansemond River site.** Kindle, E.C.; Bandy, E.C.; Copeland, G.; Blais, R.; Levy, G. (Old Dominion Univ., Norfolk, Va. (USA). Research Foundation). May 1975. Contract NGL-47-003-067. 261p. (NASA-CR—142821). NTIS $8.50.

Background data were provided for the assessment of the environmental impact of a proposed oil refinery location. Climatic background, particulate data, digitized portrayal of site molecular and meteorological data, graphical portrayal of molecular data, hourly meteorological data, and streamflow charts and radiosonde data are given (GRA)

## STORAGE

*REFER ALSO TO CITATION(S) 5228, 5229*

## COMBUSTION

*REFER ALSO TO CITATION(S) 4436*

# NATURAL GAS

*REFER ALSO TO CITATION(S) 4368, 4369*

**4459 Material handling methods and innovations.** Hawkins, J.H. (Memphis Light, Gas, and Water Division, TN). *Am. Gas Assoc., Oper. Sect., Proc.*; D165-D166(1975).

Ideas and procedures are presented by area and function within the areas.

**4460 American gas association 1975 operating section proceedings.** (Am Gas Assoc, Arlington, Va). *Am. Gas Assoc., Oper. Sect., Proc.*; (1975).

One hundred twenty two papers of the Distribution and Transmission Conference by various authors are presented. The topics discussed are: operation, supply, automotive and mobile equipment, emission controls, mechanics, safety, oils, fuel conservation, equipment, gas quality, pipelines, corrosion, customer service, heating, distribution, construction, maintenance, personnel, piping systems, plastic pipes, measurement, meter repair, exploration, production materials, utilities, coal conversion, automation and communications, compressors, noise, operations analysis, exploration and production, automated measurement, LNG, underground storage, odorization, mains, vendors, conservation, quality control, insulating, SNG, liquefaction, computer applications, fire protection, gas from coalbeds, and coal conversion and utilization R and D. Selected papers are indexed separately.

## EXPLORATION

*REFER ALSO TO CITATION(S) 4447, 4448, 5634*

## DRILLING, PRODUCTION, AND PROCESSING

*REFER ALSO TO CITATION(S) 4452, 4508*

**4461 Deep onshore drilling prospects for the lower 48 states.** Hefner, R.A. III. *Am. Gas Assoc., Oper. Sect., Proc.*; T58-T60(1975).

The 'Oklahoma Experience' with natural gas is evaluated regarding present and future reserves. 9 refs.

**4462 Trans-Alaska gas project.** Lister, J.P. (El Paso LNG Co., TX). *Am. Gas Assoc., Oper. Sect., Proc.*; T114-T116(1975).

Detailed description and estimated cost calculation is presented.

**4463 Additional considerations for offshore measurement.** Rau, R.J. (Transcont Gas Pipe Lin Corp., Houston, TX). *Am. Gas Assoc., Oper. Sect., Proc.*; T187-T188(1975).

Procedures are presented in tabular form.

## PRODUCTS AND BY-PRODUCTS

**4464 Effects of oxygen and other trace elements on liquefaction plant operation.** Schmid, W.E.; Linde, W. *Am. Gas Assoc., Oper. Sect., Proc.*; T86-T87(1975).

Water vapor, carbon monoxide, mercury, pentane, hexane, methanol, refrigerants, glycol and amines, and other potentially detrimental mixtures are discussed and tabulated.

## HEALTH AND SAFETY

*REFER ALSO TO CITATION(S) 4504, 4521*

**4465 (PB—241845) Study to evaluate the tools and procedures for assessing the safety of existing gas distribution systems. Final report.** Bartol, J.A.; Nichols, R.O. (AMF, Inc., Goleta, Calif. (USA). Advanced Systems Lab.). Jan 1975. Contract DOT-OS-40182. 199p. NTIS $7.00.

The study aimed at finding how the safety of natural gas distribution systems is related to their physical condition. The physical methods and equipment presently being used by gas distribution system companies for this purpose were reviewed and evaluated, as well as statistical data on leaks and failures. A review was made of (a) nondestructive testing techniques that appear applicable to the problem, and (b) current research and development directed to distribution system evaluation. An assessment was made of relative cost effectiveness of the various techniques. (GRA)

**4466 Upgrading LNG plant safety.** Brock, N.H. Jr.; Howard, R.M. *Am. Gas Assoc., Oper. Sect., Proc.;* T83-T85(1975).

Evaluation of operating and design methods, and of equipment is presented.

**4467 Considerations relating to fire protection requirements for LNG plants.** Wesson, H.R. *Am. Gas Assoc., Oper. Sect., Proc.;* T121-T136(1975).

Recommendations on the type of potential fire, vapor dispersion and safety hazards that should be considered in the initial design phases of LNG facilities are presented and discussed. Bibliographies of applicable technical publications relating to each type of potential hazard are presented in a sectionalized format. Recommendations on the design parameters for LNG spill vapor dispersion control, LNG spill fire control, radiation exposure control and LNG facility fire extinguishing systems are presented and discussed in tabular and equation form. 115 refs.

## MARKETING AND ECONOMICS

*REFER ALSO TO CITATION(S) 4461, 4476, 5223*

**4468 Estimating loads for individual consumers in a retail gas distribution system.** Ferber, E.P. *Am. Gas Assoc., Oper. Sect., Proc.;* D133-D136(1975).

A new computerized method has been developed which calculates load estimating factors for nearly all residential and commercial consumers. This includes consumers whose meters could not be read during most billing periods. Diagrams and equations illustrate method.

**4469 Evaluating vendors: bid prices vs real price.** Strider, W.P. *Am. Gas Assoc., Oper. Sect., Proc.;* D142-D145(1975).

A Supplier Evaluation Program is presented in tabular form.

**4470 Capital requirements for the natural gas industry.** Hill, K.E. *Am. Gas Assoc., Oper. Sect., Proc.;* D159-D162(1975).

A tabulated survey of energy balances and estimated expenditures in unregulated and regulated conditions is presented. 1 ref.

**4471 New concept in materials distribution.** Meyers, E.J. *Am. Gas Assoc., Oper. Sect., Proc.;* D163-D164(1975).

A cost saving system resulting in improved control is described. Consolidation of material supply points is emphasized, and cost analysis is tabulated.

**4472 LNG from indonesia: prospects and problems.** Todd, R.W. *Am. Gas Assoc., Oper. Sect., Proc.;* T110-T113(1975).

Facilities, transfer of title, shipping, penalties, government approvals, and currency adjustment are discussed.

## ENVIRONMENTAL EFFECTS

**4473 Polar gas project: progress report.** Hindle, W. *Am. Gas Assoc., Oper. Sect., Proc.;* T157-T160(1975).

Feasibility aspects are discussed.

## POLICY, LEGISLATION, AND REGULATION

*REFER ALSO TO CITATION(S) 4462, 4467, 4472, 4506, 4513*

**4474 Operation confidence.** Gauthier, C.J. *Am. Gas Assoc., Oper. Sect., Proc.;* D1-D2(1975).

Economic, financial, and pricing policy of the industry is analyzed.

**4475 Gas supply and curtailment policy from a regulator's point of view.** Wickberg, R.H. *Am. Gas Assoc., Oper. Sect., Proc.;* D3-D4(1975).

Legislative aspects of the industry are reviewed.

**4476 Sng supply and demand.** Hardy, E.F. (American Gas Association, Arlington, VA). *Am. Gas Assoc., Oper. Sect., Proc.;* T161-T163(1975).

The overall U.S. gas supply situation, within which SNG fits as one part, is reviewed. An abbreviated history and analyses of specific weaknesses in the federal government's evaluation of SNG projects are presented in graphical and tabular form.

## TRANSPORT, PIPELINES, AND HANDLING

*REFER ALSO TO CITATION(S) 4463, 4465, 4467, 4519*

**4477 (KFK-PDV—66) Computer program GANESI: description of a computer program for the simulation of unsteady flows in gas distribution networks.** Weimann, A.; Wanka, K. (Gesellschaft fuer Kernforschung m.b.H., Karlsruhe (Germany, F.R.)). Jan 1976. 30p. (In German). Dep. NTIS (US Sales Only) $4.00.

Models for the simulation of the dynamics of gas distribution networks play an important role for design and control of these processes. In this report the computer program GANESI for the simulation of unsteady flows in gas distribution networks is described. Network modelling, applications, and handling of the program are discussed. The validity and efficiency of the program are demonstrated by calculated network examples.

**4478 Some important factors in LNG tanker design selection.** Ffooks, R.C. (Conch Methane Services Ltd., London). *Adv. Cryog. Eng.;* **19**: 269-275(1974).

Guidelines for criteria in factors to be considered in ship selection are outlined.

**4479 Application of noise abatement techniques.** Schwab, R. (Fisher Controls Co., Marshalltown, IA). *Am. Gas Assoc., Oper. Sect., Proc.;* D120-D124(1975).

Practical examples are given together with graphical and tabular representation.

**4480 Calculating optimum pipeline operations.** Zimmer, H.I. (El Paso National Gas Co., TX). *Am. Gas Assoc., Oper. Sect., Proc.;* T54-T57(1975).

The objective of the optimization is to find the operation of an unloaded pipeline system which minimizes the fuel consumed in transporting the given supply to market. Stated in terms of station set point pressures and the associated pipeline pressures. The calculation specifies the operation of each compressor unit giving data such as required horsepower, fuel consumption, compressor speed, efficiency, and pocket settings. Data are shown in graphical form. 2 refs.

**4481 Current NIOSH activities in the development of criteria documents.** Nifong, G.D. *Am. Gas Assoc., Oper. Sect., Proc.;* T203-T204(1975).

Administrative aspects of safety measures are discussed.

**4482 Gas pipeline leak location and measurement.** Graf, F.L. (Philadelphia Electric Co., PA). *Am. Gas Assoc., Oper. Sect., Proc.;* D42-D44(1975).

Use of deep probes in air and vacuum testing to reduce repair expenses is discussed.

**4483 Insulating requirements to protect existing coated distribution systems.** McAmis, J.W. *Am. Gas Assoc., Oper. Sect., Proc.;* D46-D47(1975).

Anti-corrosion measures and procedures are described.

**4484 Protecting bare steel: choosing the proper criterion.** Sharp, J.W. *Am. Gas Assoc., Oper. Sect., Proc.;* D48-D49(1975).

Testing methods are described and explained.

**4485 Leak survey quality index.** Fisher, R.M. *Am. Gas Assoc., Oper. Sect., Proc.;* D72-D74(1975).

Control system and practice are discussed and presented in graphical form.

**4486 Use of customer odor complaints in determining adequacy of odorization.** Dickson, L.L. *Am. Gas Assoc., Oper. Sect., Proc.;* D78-D79(1975).

Odorant effectiveness monitoring using a computer program is explained, and report forms are shown.

**4487 New life for old gas mains.** Steinmetz, G.F. (Baltimore Gas and Electric Co., MD). *Am. Gas Assoc., Oper. Sect., Proc.;* D92-D93(1975).

Prevention and stopping of leakage is discussed.

**4488 User evaluation of distribution system components.** Needham, D. *Am. Gas Assoc., Oper. Sect., Proc.;* D108-D117(1975).

Results of a thorough testing program of British Gas Corp. are presented in graphical and tabular form.

**4489 Gas flow formulas: strengths, weaknesses and practical applications.** Hyman, S.I.; Stoner, M.A.; Karnitz, M.A. (Brooklyn Union Gas Co., NY). *Am. Gas Assoc., Oper. Sect., Proc.;* D125-D132(1975).

A unified approach is presented in graphical, tubular, and equation form, and expressed in SI units. 5 refs.

**4490 Sonic nozzles in distribution metering.** Schroyer, H.R. *Am. Gas Assoc., Oper. Sect., Proc.;* D137-D141(1975).

Calibration procedures are explained and graphical, tabular, and equation form.

**4491 Performance: plastic vs steel piping.** Petro, P.P. *Am. Gas Assoc., Oper. Sect., Proc.;* D167-D170(1975).

A comparative tabulated survey is presented.

**4492 Static electricity and lightning effects on plastic pipe.** Davis, G.W. *Am. Gas Assoc., Oper. Sect., Proc.;* D175-D177(1975).

Results of laboratory and research studies are reported, and prevention measures are recommended. 7 refs.

**4493 Determination of stresses and structural performance in polyethylene gas pipe and socket fittings due to internal pressure and external soil loads.** Allman, W.B. *Am. Gas Assoc., Oper. Sect., Proc.;* D178-D195(1975).

Techniques and experimental work as it applies to polyethylene pipe and socket fittings and procedures which provide a basis for polyethylene gas distribution system design are discussed and presented in graphical, tabular, and equation form. 7 refs.

**4494 Controlling a 25,000 h.p. gas compressor station with a mini-computer.** Montgomery, P.R. (Transcontinental Gas Pipe Line Corp., Houston, TX). *Am. Gas Assoc., Oper. Sect., Proc.;* T11-T15(1975).

Relay-logic supervisory system is described and presented in graphical forces.

**4495 Fully automated gas storage field.** Byrne, J.J.; Lu, T.A. *Am. Gas Assoc., Oper. Sect., Proc.;* T16-T21(1975).

The system startup, production, and shutdown operations are fully automated using a real time process digital computer at each station. A well test program is also implemented to monitor the condition of each well. The design and construction of these stations are based on the concepts of full automation and centralization with emphasis on system reliability and safety. 3 refs.

**4496 Exhaust emissions from piston and gas turbine engines used in natural gas transmission.** Springer, K.J.; Dietzmann, H.E. (Southwest Research Inst., San Antonio). *Am. Gas Assoc., Oper. Sect., Proc.;* T26-T32(1975).

Procedural development and baseline emission rates are analyzed and test results are presented in a tabular and graphical form. 4 refs.

**4497 Possible efficiency improvements related to integral angle compressors.** Helmich, M.J.; Hartwick, W.F. (Cooper-Bessemer Co., Mt. Vernon, OH). *Am. Gas Assoc., Oper. Sect., Proc.;* T38-T47(1975).

Analysis of scavenging, ignition timing, cooling, valve modification, recyclindering, and other improvements is presented in graphical, tabular, and equation form. 14 refs.

**4498 Training technicians for automated stations.** Mathias, R.J. *Am. Gas Assoc., Oper. Sect., Proc.;* T48-T50(1975).

Detailed program-building instructions are presented.

**4499 Monte Carlo simulation in the design of a pipeline system.** Pasteris, R.F.; Wilborn, J.L. (Natural Gas Pipeline Co. of America, Chicago). *Am. Gas Assoc., Oper. Sect., Proc.;* T51-T53(1975).

Model based on probability theory that can adequately predict the behavior of a pipeline system is presented. This model was tested on an existing pipeline transmission system of approximately 900 miles to determine its adequacy. The effects of an expansion of this system to its throughput capacity is also demonstrated. Data are shown in tabular and equation form.

**4500 Program for natural gas supply development for transmission and distribution companies.** Gardner, D.L. *Am. Gas Assoc., Oper. Sect., Proc.;* T61-T63(1975).

Resources, prices and government regulations are discussed.

**4501 Computer error simulation as an aid to understanding orifice meter measurement.** Schmaedeke, W.; Hermanson, J. *Am. Gas Assoc., Oper. Sect., Proc.;* T70-T71(1975).

Error theory, flow error equation, and measurement procedures are discussed. 3 refs.

**4502 Dekatherm calculation: the solution to the measurement problems associated with substitute gases.** Yost, K.C. *Am. Gas Assoc., Oper. Sect., Proc.;* T72-T75(1975).

Heat unit is suggested as uniform basis for equitable energy distribution. Calculations are shown in graphical, tabular, and equation form.

**4503 Gas dispatch minicomputer nine years after.** Myers, C.H.; Witwer, W.E. Sr. *Am. Gas Assoc., Oper. Sect., Proc.;* T76-T82(1975).

Telecomputer System reproducing accurately and currently the suppliers' field measurement is described and presented in graphical form. 3 refs.

**4504 Experiences of receiving and unloading lng from an lng barge.** Peter, H. (Brooklyn Union Gas Co., NY). *Am. Gas Assoc., Oper. Sect., Proc.;* T88-T95(1975).

Design of unloading system, vapor handling, and procedures are described in view of the hazards involved. Diagrams, curves, and plates illustrate description. 1 ref.

**4505 Geysering effects in LNG lines.** Lewis, J.P.; Smith, K.A. (Transco Energy Co., Houston, TX). *Am. Gas Assoc., Oper. Sect., Proc.;* T96-T103(1975).

Anticipation of unexpected transients in pipes and use of beneficial operating effects of phenomenon are discussed and presented in graphical and equation form. 29 refs.

**4506 Status of international standards for LNG water transportation: the IMCO code for liquefied gas tankers.** Lakey, R.J. (US Coast Guard, Washington, DC). *Am. Gas Assoc., Oper. Sect., Proc.;* T117-T120(1975).

Chapter by chapter explanation and tabulated survey are presented.

**4507 Choosing a welding process for LNG piping and vessels.** Crichton, A.B.; Post, H.J.; Sosnin, H.A. (Philadelphia Gas Works). *Am. Gas Assoc., Oper. Sect., Proc.;* T137-T142(1975).

Various processes are evaluated and presented in graphical and diagrammatical form.

**4508 Construction of offshore platforms and pipelines in deep water and adverse environmental conditions.** Gordon, H.W. (Brown and Root Inc., Houston, TX). *Am. Gas Assoc., Oper. Sect., Proc.;* T143-T145(1975).

Equipment, devices, joining, foundations, and installations are evaluated.

**4509 Condensate formation in natural gas pipelines.** Katz, D.L.; Bergman, D.F. (Univ. of Michigan, Ann Arbor). *Am. Gas Assoc., Oper. Sect., Proc.;* T146-T156(1975).

Presence of small but significant amounts of hydrocarbons $C_{10}$ or heavier is discussed and methods of obtaining extended gas analyses to include these heavier hydrocarbons have been devised which permit the use of phase behavior calculations for predicting condensation conditions. These extended analyses also permit design calculations for absorption plants which will predict the gas compositions found in pipeline systems. Data are shown in graphical and tabular form. 10 refs.

**4510 Digital computers for gas measuring systems.** Jacobs, T.E. *Am. Gas Assoc., Oper. Sect., Proc.;* T189-T191(1975).

Data Acquisition and Control System (DAC) is presented in diagrammatical form.

**4511 Effect and control of pulsation in gas measurement.** Less, G.G. (National Gas Pipeline Co. of America, Chicago). *Am. Gas Assoc., Oper. Sect., Proc.;* T197-T202(1975).

Error eliminating methods are explained and presented in graphical and equation form. 8 refs.

**4512 Effect and control of corrosion in gas storage wells and lines.** Bush, H.E.; Beasley, A.E. *Am. Gas Assoc., Oper. Sect., Proc.;* T205-T208(1975).

Causes, monitoring, and corrosion rate criteria are discussed and presented on graphical, tabular, and equation form. 4 refs.

**4513 Energy conservation through underground gas storage.** Sherwood, J.P. *Am. Gas Assoc., Oper. Sect., Proc.;* T218-T221(1975).

Techniques and rates are discussed and tabulated.

**4514 Possibilities for increased underground gas storage along the Atlantic seaboard.** Winar, R.M. *Am. Gas Assoc., Oper. Sect., Proc.;* T222-T226(1975).

New concepts are discussed and presented graphically. 34 refs.

**4515 Use of storage field automation by the reservoir engineer.** Clark, W.H. *Am. Gas Assoc., Oper. Sect., Proc.;* T230-T234(1975).

The installation of automation in ten underground gas storage fields and on some 900 to 1,000 wells is surveyed and presented in graphical form. 1 ref.

## PROPERTIES

*REFER ALSO TO CITATION(S) 4505, 4509, 4641*

**4516 Calculation of LNG excess volumes by a modified hard-sphere model.** Rodosevich, J.B.; Miller, R.C. (Univ. of Wyoming, Laramie). *Adv. Cryog. Eng.;* **19**: 339-345(8 Aug 1973).

Calculations have been made for some ternary LNG mixtures for which experimental data are available. Comparisons between model prediction and experiment are presented. The liquid model of hard spheres in a uniform potential field has been modified by introduction of a third parameter dependent on molecular shape. Mixing rules have been developed so that liquid mixture excess properties can be calculated. A preliminary set of mixing rule deviation parameters has been presented.

## COMBUSTION

*REFER ALSO TO CITATION(S) 4436, 4438*

**4517 New correlation between heating values for LNG custody transfer.** Johnson, P.C.; Lewis, J.P.; Wilson, G.M. (Distrigas Corp., Boston). *Adv. Cryog. Eng.;* **19**: 346-357(1974).

Several calculation methods for heating values of liquefied natural gas are reviewed. A comparative analysis is made of results obtained from five calculation methods. Binary and multicomponent gas mixtures of two or more components were examined. These include nitrogen, methane, ethane, propane, iso-butane, n-butane, iso-pentane, and n-pentane. Compositions were chosen with heating values ranging from 1000 to 1500 Btu/scf. For comparison purposes, heating values were first calculated for assumed compositions on gas, liquid, and weight bases. A direct correlation between heating values for liquid natural gas has been found which minimizes effects from other physical properties. Thus the heating value per liquid cubic foot or per pound can be calculated from the gross heating value per standard cubic foot of vaporized gas.

## STORAGE

**4518 Effect of weathering of LNG in storage tanks.** Shah, J.M.; Aarts, J.J. (Chicago Bridge and Iron Co., Oak Brook, IL). *Adv. Cryog. Eng.;* **19**: 253-260(1974).

LNG weathering is a gradual change of the composition of the stored liquid over a period of time. As the more volatile components evaporate, the remaining liquid increases in heating value and the compatibility of this liquid with the normal gas supply must be evaluated. A mathematical analysis is developed to calculate these effects as a function of time based on a mass and energy balance. Also, a simplified procedure is shown to solve this problem by the use of thermophysical properties prediction method. Examples of weathering in a typical flat bottom, aboveground LNG tank and weathering during the cargo voyage of an LNG ship are given.

**4519 Design of LNG receiving terminals.** Crawford, D.B.; Durr, C.A. (M.W. Kellogg Co., Houston, TX). *Adv. Cryog. Eng.;* **19**: 261-268(1974).

Basic components of a receiving terminal to store the liquefied natural gas coming from various foreign sources to the USA are considered. An analysis is given on several technical problems encountered in designing of such terminals. The emphasis is focused on the ship unloading and vapor handling systems.

**4520 Structural plastic foam thermal insulation for cryogenic service.** Bennett, R.B. (Amspec Inc., Columbus, OH). *Adv. Cryog. Eng.;* **19**: 393-399(1974).

The feasibility of using plastic foams as thermal insulators for cryogenic applications is considered. One major application for a plastic foam requiring significant load-carrying requirements is the base or bottom insulation for land LNG tanks. Physical characteristics of styrofoam plastic are examined and reported.

**4521 LNG tank purging, entry, and inspection.** Devanna, L.; Doulames, G. (Lowell Gas Co., MA). *Am. Gas Assoc., Oper. Sect., Proc.;* T104-T109(1975).

Operation performed by maintaining a nitrogen atmosphere is discussed and presented in graphical and equation form.

# OIL SHALES AND TAR SANDS

*REFER ALSO TO CITATION(S) 4368, 4369*

## SITE GEOLOGY AND HYDROLOGY

### SITE GEOLOGY

**4522 Modification of the mineral matrix of Green River oil shale by bioleaching.** Meyer, W.C.; Yen, T.F. (Univ. of Southern California, Los Angeles). pp 19-33 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers Inc. (1976).

X-ray diffraction and electron microprobe studies on the mineral composition of oil shales, before and after bioleaching, are reported. It is concluded that bioleaching removes carbonate minerals from the shale, increasing porosity and permeability. Use of bioleaching as a pre-retorting step in the processing of shale is suggested. (JGB)

## DRILLING, FRACTURING, AND MINING

*REFER ALSO TO CITATION(S) 4528*

## OIL PRODUCTION, RECOVERY, AND REFINING

*REFER ALSO TO CITATION(S) 4522, 4646*

**4523 Oil shales of United States: a review.** Yen, T.F. (Univ. of Southern California, Los Angeles). pp 1-17 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers Inc. (1976).

The following topics are discussed: potential and distribution of oil shales; current recovery technology, including aboveground and in-situ processes; and petrography of Chattanooga, Appalachian, and Green River oil shales. (JGB)

**4524 Sulfur recovery by desulfovibrio in a biochemical method of oil shale production.** Kim, K.E.; Higa, J.A.; Yen, T.F. (Univ. of Southern California, Los Angeles). pp 157-162 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers, Inc. (1976).

A proposed method for dissolving the mineral matrix of oil shale, thereby freeing the incorporated kerogen, makes use of the sulfur-oxidizing bacteria, Thiobacillus spp. The action of the bacteria produces sulfuric acid which dissolves a portion of the mineral matrix. It has been estimated that 133Kg of $H_2SO_4$ is needed per ton of shale to give a weight loss of 12 percent. This initial sulfur investment can be recovered by utilizing a sulfate-reducing bacteria, i.e., Desulfovibrio sp., to regenerate sulfide from sulfate. The feasibility of coupling a reductive process using Desulfovibrio sp. with an oxidative procedure of Thiobacillus sp., for cycling of sulfur, was demonstrated. (JGB)

**4525 Microbial degradation of oil shale.** Findley, J.E.; Appleman, M.D.; Yen, T.F. (Univ. of Southern California, Los Angeles). pp 175-181 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers, Inc. (1976).

Research on the release of useful energy-containing constituents from shale using biological methods has been directed toward two aspects of the problem, solubilization of the inorganic matrix and breakdown of kerogen molecules. Solubilization of the inorganic matrix of shale has been investigated using microorgan-

isms that are able to produce large amounts of sulfuric acid, with studies centering around the use of Thiobacillus and Ferrobacillus. It has been found that a 40 percent weight loss is obtained from ground shale leached with sufficient quantities of the acid-containing bacterial culture. Attempts to break down the kerogen molecule with cultures of Alternaria sp., Aspergillum sp., Cladosporum sp., and Mydobacterium sp. have not been successful. (JGB)

**4526 Environmental improvements by oil shale leaching.** Moussavi, M.; Yen, T.F. (Univ. of Southern California, Los Angeles). pp 205-220 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers, Inc. (1976).

The geochemistry, mineralogy, trace element content, and nature of N and S compounds in oil shales are reviewed. Environmental problems associated with the processing of oil shales at high temperatures and subsequent waste disposal are discussed. Studies indicate that the leaching of oil shale (using mineral acids) prior to retorting makes possible a reduction in retorting temperature, thereby reducing the formation of certain polycondensed aromatic compounds known to be hazardous to health. In addition, waste materials are more refractive, consequently more acceptable environmentally. (JGB)

### IN SITU METHODS, TRUE AND MODIFIED

**4527 Operations and environmental considerations: Occidental Petroleum Corporation in situ operations.** Chew, R.T. III. pp 73-81 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers Inc. (1976).

Low-grade material below and within the section selected for mining is broken and mined out, providing space for rubblized ore-grade material. Air, plus recycle gas, is introduced at the top of the broken rubble pile and removed at the bottom. The pile is fired at the top, and the flame front moves forward. Products are oil, light hydrocarbons, water, and carbon. Advantages of the process from the environmental standpoint are discussed. (JGB)

### SURFACE METHODS

**4528 TOSCO-II oil shale process.** Whitcombe, J.A.; Vawter, R.G. (Oil Shale Corp., Los Angeles). pp 47-64 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers Inc. (1976).

The TOSCO-II retorting process and the processing facilities included in the design of a commercial oil shale plant are described. Economic projections are given for the production of hydrotreated shale oil and, alternatively, for crude shale oil.

**4529 Retorting indexes for oil shale pyrolyses from ethylene/ethane ratios of product bases.** Jacobson, I.A. Jr.; Decora, A.W.; Cook, G.L. (Laramie Energy Research Center, WY). pp 103-114 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers, Inc. (1976).

A method is presented for calculation of a parameter (called Retorting Index) that combines the elements of temperature and residence time to give a single number that can be used to indicate retorting conditions or to compare various thermal processing techniques for oil shale. The index was developed by relating the ethylene/ethane ratio in the product gases from retorting of shale to a measured temperature in the retorting zone. Application of the parameter to Fischer assay, gas combustion, and entrained solids retorts is illustrated with examples. (JGB)

### PURIFICATION

*REFER ALSO TO CITATION(S) 5481*

**4530 Comparison of shale gas oil denitrification reactions over Co—Mo and Ni—W catalysts.** Silver, H.F. (Univ. of Wyoming, Laramie); Wang, N.H.; Jensen, H.B.; Poulson, R.E. pp 163-173 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers, Inc. (1976).

The selectivity of three catalysts (Co—Mo on $Al_2O_3$, Ni—W on $Al_2O_3$, and Ni—W on $SiO_2$ . $Al_2O_3$) on influencing the conversion of five identifiable types of nitrogen compounds was demonstrated. The two Ni—W catalysts are somewhat more selective in converting quinoline-type compounds than is the Co—Mo catalyst. Because there is no difference in the selectivity of the two Ni—W catalysts that differ from each other in the composition of their supports, it seems likely that the active-metal component of the catalyst is the determining factor in the selectivity of quinoline conversion. At low denitrification levels all three catalysts are effective in rapidly converting indole-type nitrogen, but above 20 percent nitrogen removal, the Co—Mo catalyst is more effective than the Ni—W catalysts. All three catalysts show that they are less effective in converting arylamines than in removing nitrogen; and they show approximately the same selectivity toward primary and secondary amines. The Co—Mo catalyst converts amide-type nitrogen much faster at low levels than do the two Ni—W catalysts; but all three catalysts are highly selective in promoting conversion of amide-type nitrogen. The results also show that the relative percentages of different nitrogen compounds change as shale gas oil is denitrified. At low and intermediate levels of nitrogen removal, all five types of nitrogen compounds are present in the liquid product. However, at higher levels of nitrogen removal the identifiable nitrogen compounds remaining in the liquid product consist primarily of quinolines, indoles and arylamines. Primary and secondary amines and amides are practically missing from the product at levels approaching 80 percent removal of nitrogen.

## PROPERTIES AND COMPOSITION

*REFER ALSO TO CITATION(S) 4523, 4536*

**4531 Pulsed NMR examination of oil shales: estimation of potential oil yields.** Miknis, F.P.; Decora, A.W.; Cook, G.L. (Laramie Energy Research Center, WY). pp 35-45 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers Inc. (1976).

Two groups of oil shale samples from two different cores were analyzed by pulsed NMR in a routine assay-type operation. In cores for which adsorbed water was a contributor to the NMR signal, it was necessary to make two NMR measurements of the free induction decay amplitude to correct for this interference. Statistical analyses are presented to show that the NMR data correlate linearly with Fischer assay oil yield data. (JGB)

**4532 Mild oxidation of bioleached oil shale.** Young, D.K.; Shih, S.; Yen, T.F. (Univ. of Southern California, Los Angeles). pp 65-71 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers Inc. (1976).

Shale samples collected from the Mahogany Ledge of the Green River Formation were crushed, treated with dilute HCl, and extracted with a (4:1) benzene:methanol mixture to remove soluble material. Stepwize permanganate oxidation of the treated shale was carried out at 75°C. Oxidation products, which were identified as K salts of carboxylic acids by NMR and gas chromatography, did not include a significant quantity of aromatic protons. Results indicate that oxidative release of the entrapped organic material in an aqueous medium is possible without decomposition of the mineral matrix. (JGB)

**4533 Electrolytic oxidation and reduction of oil shale.** Wen, C.S.; Yen, T.F. (Univ. of Southern California, Los Angeles). pp 83-101 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers Inc. (1976).

Results of preliminary studies related to the electrolytic oxidation and reduction of bioleached oil shale are given. Electrolytic oxidation of HCl-leached samples similar to those resulting from bioleaching was carried out using an H-type cell. Results indicate that electrolytic oxidation is an efficient stepwize process for oxidative degradation of oil shale, also resulting in a significant reduction in S content. Electrolytic reduction of kerogen concentrate appears to be a promising technique for breaking down the cross-linked matrix of kerogen. (JGB)

**4534 Investigations of the hydrocarbon structure of kerogen from oil shale of the Green River Formation.** Schmidt-Collerus, J.J.; Prien, C.H. (Univ. of Denver). pp 183-192 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers, Inc. (1976).

By using a combination of micropyrolysis, pyrochromatography, and mass spectrometry (MPGM), it was found that kerogen consists of a three-dimensional organic matrix of high molecular weight. The hydrocarbon portion of the matrix itself appears to consist of polycyclic "protokerogen" subunits or nuclei (of tetralin, terpenoid, phenanthrenoid and steroid type structure) interconnected by long-chain alkanes and isoprenoids to form the three-dimensional network of the kerogen matrix. Studies on synthetic model compounds of the protokerogen type support this concept. However, the matrix of kerogen in the conventional term also contains a substantial amount of entrapped long-chain alkanes, normal and branched fatty acids, and other uncondensed protokerogen subunits not removed by the normal extraction process. The presence of these compounds, which appear to have been overlooked, may considerably influence the results of structural investigations reported in the literature. Morphological and physicochemical studies also indicate that Green River Oil Shale contains at least two major types of kerogen: alpha—kerogen and

beta—kerogen. These are probably of different origins. The chemical structure of the protokerogen subunits identified by macropyrolysis, chemical cleavage, and by the MPGM-method used in conjunction with reaction chromatography are described. The possiblerelationship between kerogen structure, the soluble bitumen, and the biogenesis and geochemical origin of oil shale are discussed.

**4535 Structural investigations on Green River oil shale kerogen.** Yen, T.F. (Univ. of Southern California, Los Angeles). pp 193-203 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers, Inc. (1976).

X-ray diffraction was used to study various structural parameters of kerogen concentrate from Green River oil shale. It is concluded that there are few aromatic carbon skeletons in kerogen. The bulk of the carbon structure is naphthenic, containing 3 to 4 rings. No free-end and flexible long-chain linear polymethylene structures are present. The C/O atomic ratio of kerogen was found to be 18; the distribution of oxygen functional groups is predominantly of ether type (53 percent) and ester type (25 percent). Studies indicate that kerogen is a multipolymer consisting of monomers of bitumen origin, and involving both primary and secondary bonding. A hypothetical model is proposed for the structure of kerogen and its relation with bitumen. (JGB)

## HEALTH AND SAFETY

**4536 Polycondensed aromatic compounds (PCA) and carcinogens in the shale ash of carbonaceous spent shale from retorting of oil shale.** Schmidt-Collerus, J.J.; Bonomo, F.; Gala, K.; Leffler, L. (Denver Research Inst.). pp 115-156 of In Science and technology of oil shale. Yen, T.F. (ed.). Ann Arbor; Ann Arbor Science Publishers, Inc. (1976).

Studies were initiated to determine experimentally possible specific physical environmental effects (near and long-term) from solid carbonaceous material from an oil shale industry. In order to establish a base line for future comparative studies, samples of soil, water vegetation, and air from various pristine areas of potential future oil shale operations were collected and partially analyzed for their content of polycyclic organic matter, in particular polycondensed aromatic hydrocarbons (PAH). Samples of carbonaceous spent shale were collected and analyzed for their content of volatile organic as well as polycondensed aromatic compounds. Results indicate that carbonaceous spent shale with up to 5 percent organic carbon content contains material soluble in organic solvents. The PAH compounds identified to date in the benzene-soluble portion include compounds such as benzo(a)pyrene, 1.2-benzanthracene, and dibenzacridine. In addition to these PAH compounds, the presence of a larger number of azarines and some carbazoles is indicated.Preliminary data indicate that a larger number of polycyclic aromatic compounds (including those with known adverse biological activity) can be leached from the carbonaceous shale and migrate with the saline water. The extracted water-soluble salts from carbonaceous spent shale contain from 20 to 40 percent of the total benzene-extractable organic matter of the original carbonaceous spent shale. (JGB)

## WASTE RESEARCH AND MANAGEMENT

*REFER ALSO TO CITATION(S) 4526*

## ENVIROMENTAL ASPECTS

*REFER ALSO TO CITATION(S) 4536*

# FISSION FUELS

## RESERVES

*REFER ALSO TO CITATION(S) 5183*

**4537 (K-TL—524(Pt.5)) National Uranium Resource Evaluation Program. Hydrogeochemical and Stream Sediment Reconnaissance Program in Central United States. Fourth Quarter FY 1976, April 1, 1976—June 30, 1976.** Arendt, J.W. (Oak Ridge Gaseous Diffusion Plant, Tenn. (USA)). 6 Aug 1976. Contract W-7405-eng-26. 29p. Dep. NTIS $4.00.

The production sampling program for the Uranium Resource Evaluation (URE) Project continued in the Texas Gulf Coast area. Pilot surveys were completed in the Llano, Texas area, Texas Panhandle, Oklahoma, and Kansas. Plans for production sampling in the Texas Panhandle, and for conducting pilot surveys in Minnesota, North Dakota, South Dakota, Wisconsin, and Michigan are now complete. Pilot survey, production, and quality control (QC) samples are being analyzed in the URE Clean Room Laboratory and the results recorded in the URE data base. Plans were implemented for receiving, handling, and retrievable storage of URE samples. A project status and summary of UCC-ND activities during the quarter are presented in this report. Also included is a listing of plans for FY 1976A. (auth)

**4538 (N—75-26482/0ST) Application of remote sensor data to geologic analysis of the Bonanza test site Colorado. Semiannual progress report, 1 Oct 1974—31 Mar 1975.** Lee, K. (Colorado School of Mines, Golden (USA). Dept. of Geology). Apr 1975. Contract NGL-06-001-015. 20p. (NASA-CR—143082; RSR—75-2). NTIS $3.25.

Selected samples of anomalous surface features commonly associated with the various types of uranium deposits are presented, and recommendations for sensor applications are given. The features studied include: epigenetic uranium ore roll type; precambrian basal conglomerate type; vein-type uranium deposits; pipe-structure or diatreme deposits; evaporitic uranium deposits. The hydrogeology of the Mosquito Range and the San Luis Valley is also examined. (Author) (GRA)

**4539 (ERDA-tr—123) Symposium at the Equator.** Goedkoop, J.A. Translated by I.A. Leonard from *Atoomenerg. Haar Toepass.*; **17**: No. 12, 260-272(Dec 1975). 24p. (CONF-750641—4). Dep. NTIS $3.50.

From IAEA international symposium on the Oklo phenomenon; Libreville, Gabon (23 Jun 1975).

From June 23 to 27, 1975, a symposium was held in Gabon on the Oklo Phenomenon. This document discusses the discovery of the phenomenon, the air trip to the meeting site, the origin of the natural reactors in the Francevillien formation, the sequence of events in the past, average power, reactor physics aspects, reaction duration and power, fine structure of reactors, decay, fission products, etc. The question of whether the Oklo Phenomenon is unique is addressed. (DLC)

**4540 Issue of uranium availability.** Hogerton, J.F. (S.M. Stoller Corp., New York). *Trans. Am. Nucl. Soc.*; **23**: 243-244(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## EXPLORATION

*REFER ALSO TO CITATION(S) 5470*

**4541 Natural gamma radiation borehole logging system.** (to Mobil Oil Corp., New York (USA)). Netherlands Patent 7,500,947/A/. 27 Jan 1975. 12p. (In Dutch).

Priority 15 Feb 1974, USA; 4 figs.

A borehole logging system employs a gamma detector for measuring the natural gamma radiation of the earth formations surrounding a borehole. Three energy band selectors, each employing a discriminator and count rate meter, separate the output of the gamma-ray detector into potassium, uranium and thorium energy band signals. A first operational amplifier determines the differences between the potassium energy band signal and those portions of the uranium and thorium energy band signals which represent the influence of uranium and thorium gamma radiation within the potassium energy band, this difference representing the correct potassium gamma radiation. A second operational amplifier determines the difference between the uranium energy band signal and that portion of the thorium energy band signal which represents the influence of the thorium gamma radiation within the uranium energy band, this difference representing the correct uranium gamma radiation. A third operational amplifier determines the difference between the thorium energy band signal and that portion of the uranium energy band signal which represents the influence of the uranium gamma radiation within the thorium energy band, this difference representing the correct thorium gamma radiation.

**4542 Frontiers of uranium exploration.** Gabelman, J.W. (Atomic Energy Commission, Washington, DC). *Trans. Soc. Min. Eng. AIME*; **258**: No. 1, 7-19(Mar 1975).

The predicted growth of uranium demand far in excess of estimated resources is an incentive to examine current technology for data or promising techniques that might foster discovery by technical prediction rather than by systematic drilling. The world could well be reexamined systematically with new geophysical techniques including gamma spectrometry, radon emanometry, and magnetometry. Known occurrences could well be reevaluated in the light of new data on mineralization process and supergene leaching. Less-leachable extrinsic elements associated with uranium might be sought as clues to unleached uranium at depth. Uranium is increasingly being noted in environments containing coal and petroleum which might become targets. High-temperature replacement disseminations are increasingly reported and particularly attractive as exemplified by the Roessing district. The number of formations containing uranium occurrences is growing so that new, not necessarily fluvial, formations might be productive. Enough drilling has been done to indicate that uranium is selectively distributed regionally under some control yet to be determined. Exploration should address those environments and areas where uranium could occur rather than only those where it is already known.

**4543 Results from a new uranium exploration method.** Gingrich, J.E. (Terradex Corp., Walnut Creek, CA). *Trans. Soc. Min. Eng. AIME;* **258**: No. 1, 61-64(Mar 1975).

The new Track Etch technique for uranium exploration has been utilized in several survey programs conducted during the last few years. The results from these programs have been very encouraging, and new uranium ore bodies have been discovered by using this new technique. The method is being used in several exploration programs in various locations around the world. This exploration technique utilizes small pieces of special radiation-sensitive plastic film to detect the presence of radon gas which is released by uranium ore bodies. Because of the selectivity and sensitivity of the technique, ore bodies not normally detected with other surface or airborne monitoring methods are found. Since no large equipment or special training of personnel is needed, the technique is easily used in field operations. The basis for the Track Etch method, its application in field exploration programs, and the results obtained to date in locating uranium ore bodies are discussed.

**4544 Mining industry and explorations for uranium ore--the situation in Europe.** Lange, G. *Glueckauf;* **112**: No. 6, 276-280(18 Mar 1976). (In German with English abstract).

In connection with the long-term planning for an extension of the peaceful uses of nuclear energy, there have been more exploration efforts for deposits of uranium ore in the West European countries. However, only modest success could be reached, except in France. Tables and map show data. 7 refs.

## MINING

**4545** (BM-RI—8100) **Data-acquisition system for radon monitoring.** Franklin, J.C.; Zawadzki, R.J.; Meyer, T.O.; Hill, A.L. (Bureau of Mines, Washington, D.C. (USA)). 1976. 19p. Bureau of Mines, Washington, DC.

A data-acquisition system was designed by the Bureau of Mines to monitor five detectors with radon continuously flowing through each. These detectors could be monitored up to 12 times an hour, but were only monitored according to a preset time, thus allowing radon to be monitored continuously in a uranium mine. The counter can be set to monitor each detector for any period of time up to 16.5 minutes. This allows very low concentrations to be monitored longer to reduce statistical error. There would be no upper limit in radon concentration that could be monitored, but there would be a lower limit of 50 pCi/l. Each detector was calibrated by the Lucas flask method. Multiple samples were taken at two different concentrations, and the correction factor for each detector was determined by a least squares fit of the data. To verify the calibrations, a series of measurements at several concentrations were made against a constant source. The agreement at low radon concentrations (300 pCi/l) with the two-filter method was within 3 percent; thus, the total error would be this difference plus the two-filter error. At high concentrations, the coefficient of variation ranged between 2.1 and 9.8 percent for the five different detector units.

**4546** (BM-TPR—93) **Continuous radon gas survey of the Twilight mine.** Franklin, J.C.; Marquardt, R.F. (Bureau of Mines, Washington, D.C. (USA)). Jan 1976. 16p. Bureau of Mines, Washington, DC.

A radon survey was made at five different locations in the Twilight mine near Uravan, Colo., to determine changes in radon concentrations in an inactive mine. Data were taken with a continuous monitor set for 1-minute count periods and readings were taken 24 hours a day for 9 days. The 12 readings per station each hour accurately showed how the radon concentration varied during the day. From the data collected from the intake portal to station 4, the average radon emanation rate was estimated at 18 pCi/s/ft$^2$. A daily cycle in radon concentration was detected that apparently was related to barometric pressure change.

**4547 Use of a penetrant dye to study ore permeability.** Kaiman, S. (Dept. of Energy, Mines, and Resources, Mines Branch, Ottawa). *Can., Mines Branch. Tech. Bull.;* (Jan 1973).

Tests showed that fractures and porous mineral constituents in rock specimens can be revealed by wetting the specimens with Zyglo, a surface-active oil. The fluorescence of Zyglo under ultraviolet light makes it possible to study the extent of its penetration and thus to assess the permeability of the ore. Application of the technique to a radioactive conglomerate confirmed the suspected coincidence of permeable zones in the ore and uranium mineral concentrations. This could explain the amenability of the ore to leaching. Data are shown in graphical and tabular form. 2 refs.

**4548 Scientific blasting for in-situ leaching proves successful at agnew lake mines.** Lang, L.C.; Morrey, W.B. (Can Ind Ltd, MacMasterville, Quebec). *Eng. Min. J.;* **177**: No. 1, 100-102(Jan 1976).

The first Canadian application of in-situ leaching of blasted ore was staged recently in an experimental stope at Agnew Lake Mines Ltd., about 37 mi west of Sudbury, Ont. The blast design and development pattern were devised to leach in-situ a steeply dipping, tightly bound uraniferous conglomerate. The successful test at Agnew Lake required careful consideration of the location and geometry of the orebody. The planning and the matching of explosives to specific rock properties were unique. The Agnew Lake experiment is one of a continuing series of breakthroughs in solution mining technology. 7 refs.

## FEED PROCESSING

*REFER ALSO TO CITATION(S) 4575, 5480, 5521*

**4549** (BM-RI—8099) **Radium removal from uranium ores and mill tailings.** Borrowman, S.R.; Brooks, P.T. (Bureau of Mines, Washington, D.C. (USA)). 1975. 12p. Bureau of Mines, Washington, DC.

Mill tailings from conventional uranium extraction processes contain nearly all of the radium originally in the ore. Such tailings require controlled storage in perpetuity to safeguard the surrounding environment from radioactive contamination. Alternatives to controlled storage of the tailings are (1) removal of the radium from the tailings for separate storage or use or (2) removal of the radium when processing the uranium ore. In laboratory tests, radium was leached from tailings using either hydrochloric acid or ethylenediamine tetraacetic acid. A hydrochloric acid leaching method was used to extract both radium and uranium from the ore to yield tailings containing less radium than those produced by either conventional sulfuric acid or alkaline leaching processes. From 77 to 94 percent of the radium in mill tailings was concentrated by sedimentation in slime fractions representing nearly 25 wt percent of the original sample.

**4550 Method for separating metal ions of groups II and III from uranium.** Sundar, P.S. (to Westinghouse Electric Corp., Pittsburgh, Pa. (USA)). French Patent 2,241,620/A/. 20 Aug 1974. 15p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 23 Aug 1973, USA.

The separation of metal ions of groups II and III from uranium, in an aqueous solution containing uranyl ions is described. The method comprises the following steps: extracting the solution by means of a suitable solvent containing a reagent likely to react with the uranyl ion and provide a complex which is soluble in the solvent; mixing said solvent with an aqueous solution containing ammonium carbonate and/or di-carbonate in the proportion of from 0.5 to 1 mole per liter, sufficient amount of sulphite ions for causing the metal ions to precipitate; letting said solvent be separated from the aqueous solution; collecting the metal ion precipitate. That inexpensive method provides ceramic grade uranium, which can be used as reactor fuel.

**4551 Processing of wolframite-cassiterite concentrate for brannerite removal.** Born, C.A.; Queneau, P.B.; Ronzio, R.A. *Trans. Soc. Min. Eng. AIME;* **258**: No. 3, 218-221(Sep 1975).

Application of sulfuric acid-sodium chlorate leaching for substantial elimination of the radioactive impurities, particularly

the mineral brannerite is described in graphical, tabular, and equation form. 10 refs.

**4552 Concentration of gold, sulphide minerals, and uranium oxide minerals by flotation from ores and metallurgical plant products.** Weston, D. US Patent 3,964,997. 22 Jun 1976. Filed date 26 Sep 1974. 18p.

A process is described for the concentration by flotation of gold, gold bearing minerals and uranium oxide minerals from ores and metallurgical plant products. A pulp of a ground ore is agitation conditioned in at least two agitation conditioning stages wherein in at least one stage the pH of the pulp is lowered with an acid agent to within the pH range of about 1.5 to 5.0, and wherein in at least one additional agitation conditioning stage the pH of the pulp is raised to within the pH range of about 6.0 to 11.0 and wherein in at least the last stage prior to flotation at least one collector selected from the group of sulfhydryl anionic collectors is present. Subsequently, the at least two stage agitation conditioned pulp is subjected to flotation to produce a flotation concentrate enriched in at least one of the mineral values from the group consisting of gold, gold bearing minerals and uranium minerals.

**4553 Method of recovering uranium.** Tabata, T.; Ikushige, T. (to Toyo Soda Manufacturing Co., Ltd.). US Patent 3,965,238. 22 Jun 1976. Priority date 31 Jul 1972, Japan. 4p.

Uranium values are obtained from phosphate rock by acidifying phosphate rock containing uranium and at least one other heavy metal with a mineral acid solvent extracting the thus obtained crude acid with an organic solvent so as to separate a raffinate from a relatively pure, wet process phosphoric acid and treating said raffinate with a base so as to raise the pH to 1—2 whereby uranium hydroxide or phosphate and other heavy metal hydroxides or phosphates are coprecipitated. The uranium content of the coprecipitate after drying is at least as high as 0.3 percent which is comparable to that of uranium ores of the highest quality.

**4554 Uranium complex recycling method of purifying uranium liquors.** Elikan, L.; Lyon, W.L.; Sundar, P.S. (to Westinghouse Electric Corp.). US Patent 3,966,873. 29 Jun 1976. Filed date 1 Nov 1973. 10p.

Uranium is separated from contaminating cations in an aqueous liquor containing uranyl ions. The liquor is mixed with sufficient recycled uranium complex to raise the weight ratio of uranium to said cations preferably to at least about three. The liquor is then extracted with at least enough non-interfering, water-immiscible, organic solvent to theoretically extract about all of the uranium in the liquor. The organic solvent contains a reagent which reacts with the uranyl ions to form a complex soluble in the solvent. If the aqueous liquor is acidic, the organic solvent is then scrubbed with water. The organic solvent is stripped with a solution containing at least enough ammonium carbonate to precipitate the uranium complex. A portion of the uranium complex is recycled and the remainder can be collected and calcined to produce $U_3O_8$ or $UO_2$.

**4555 Method of defluorinating uranium compositions in a calciner.** Keith, W.G.; Ferris, F.D. (to General Electric Co.). US Patent 3,969,477. 13 Jul 1976. Filed date 4 Mar 1974. 10p.

A method of dehalogenating a particulate composition in a calciner having a heating zone and a cooling zone is presented in which a dehalogenating atmosphere flows through the calciner, including a constricted zone in the calciner, countercurrent to the movement of the composition through the calciner. There is practiced a step of constricting the passage of the controlled atmosphere to a zone of greater flow velocity so that the flow of the dehalogenating atmosphere through the constricted zone substantially minimizes diffusion into the cooling zone of the gaseous impurities removed from the particulate composition in the heating zone.

**4556 Multiple gas streams in the post oxidation step in a process for converting uranium hexafluoride to uranium oxide rich compositions.** Jeter, D.W.; Keith, W.G. (to General Electric Co.). US Patent 3,970,581. 20 Jul 1976. Filed date 12 May 1975. 12p.

This invention presents a process for conversion of gaseous uranium hexafluoride to an oxide product of uranium by introducing to a reaction zone in the presence of an active flame maintained in the reaction zone a first gaseous reactant comprising a mixture of uranium hexafluoride and an oxygen-containing gas and a second gaseous reactant comprising a reducing gas and temporarily separating the first and second gaseous reactants with a shielding gas which temporarily prevents substantial mixing and reaction between these gaseous reactants. The first and second gaseous reactants ultimately react in a primary flame to give a particulate uranium dioxide rich composition and residual reducing gas. An oxygen-containing gas as a third gaseous reactant is introduced through multiple downstream inlets with the inlet closest to the primary flame being at a location in the reaction zone where the uranium hexafluoride conversion to the uranium dioxide rich composition is substantially complete. Another embodiment of the process has the first gaseous reactant comprised of a mixture of uranium hexafluoride and a reducing gas and the second gaseous reactant comprised of an oxygen-containing gas. These processes result in oxidizing the uranium dioxide rich composition to a higher oxide of uranium with conversion of the residual reducing gas to its oxidized form.

**4557 Process for the production of uranium trifluoride.** Tagawa, H. (to Japan Atomic Energy Research Inst.). US Patent 3,976,750. 24 Aug 1976. Priority date 26 Dec 1976, Japan. 4p.

The method for producing a pure uranium trifluoride efficiently comprises heating a mixture of uranium tetrafluoride and uranium nitride in an inert gas stream or under vacuum.

## ENRICHMENT

**4558 Separation nozzle process of uranium enrichment: a contribution to ensuring the nuclear fuel supply of the Federal Republic.** Voelcker, H. *VGB Kraftwerkstech.;* **55**: No. 12, 811-814(Dec 1975). (In German).

A description is given of a small prototype uranium separation stage which has been in operation at the Nuclear Research Center in Karlsruhe since the end of 1973. Particular attention is paid to the design of a prototype vacuum-tight, fast-closing cutoff valve required for successful operation of a separation nozzle cascade. The object of these efforts is to create a proven, exportable technology which can be applied in commercial enrichment plants.

### GASEOUS DIFFUSION

*REFER ALSO TO CITATION(S) 5475*

**4559 (GAT—225(Rev.3)) Nuclear safety guide for the Portsmouth Gaseous Diffusion Plant.** Feuerbacher, J.L. (comp.). (Goodyear Atomic Corp., Piketon, Ohio (USA)). 30 Jun 1976. Contract E(33-2)-1. 121p. Dep. NTIS $5.50.

Safe geometrical, mass, and concentration limits are presented, together with the criticality control methods currently in use at the Portsmouth Gaseous Diffusion Plant. Basic information presented includes technical background, experimental data, and the best values inferred from experiments. Various tables and graphs are included. Design criteria include basic assumptions, fundamentals, concepts, applicable methods, and maintenance of safe geometry. Operating criteria include the operating philosophy at the Goodyear Atomic Corporation Gaseous Diffusion Plant and applied operating techniques. The appendixes contain graphs, figures, a chart showing Goodyear organization for nuclear safety, a glossary, tables of critical values, methods for calculating solid angles, and the bases for safe handling of high-uranium-density compounds and uranium metal in various forms. A list of references is also included. This Second Revision is being issued to make many minor corrections to or modifications of Revision 1 and to deal with problems arising from the appearance on plantsite of uranium metal. Calculational methods for multiplication factor, formerly included as Appendix G, will be found in a separate document, GAT-T-692, Revision No. 1.

### LASER EXCITATION

**4560 Process and apparatus for separating particles such as a $U^{235}$ isotope from a plasma.** Janes, G.S. (to Jersey Nuclear-Avco Isotopes, Inc., Bellevue, Wash. (USA)). French Patent 2,216,006/A/. 16 Nov 1973. 17p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 02 Feb 1973, USA.

A method and an apparatus to separate an isotope selectively ionised for isotopic enrichment purposes, are described. The apparatus features a source of matter such as uranium, vapourised by a heat source along a duct to cause a radially expanding flow of vapour which will then enter compartments formed between long electrodes and shorter electrodes placed radially, the apparatus possessing a device to set up a longitudinal magnetic field and a device to set up voltage impulses between the electrodes so that the electrons flow along closed paths around each electrode and the ions of the required isotope are collected on the electrodes. The process applies to the separation of the isotope U235 from natural uranium or from the spent uranium of a nuclear fuel.

**4561 Process and apparatus to separate one isotope by selective ionisation.** Kantrowitz, Arthur. (to Jersey Nuclear-Avco

Isotopes, Inc., Bellevue, Wash. (USA)). French Patent 2,216,007/A/. 16 Nov 1973. 17p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 02 Feb 1973, USA.

A process and an apparatus to separate a particular isotope by selective ionisation from a substance containing several isotopes are described. The apparatus features two lasers with their beams combined to form one beam which is sent through at least one separation chamber containing an ion separator, an isotope vapour source, a system to set up a longitudinal magnetic field through the separator, a device to produce current impulses between separator and source and a vacuum system so that the ions of the required isotope alone are ionised and directed towards the collecting plates of the separator. The process is suitable in particular for isotope U235 separation with a view to uranium enrichment.

**4562 Process for isotope enrichment.** Levy, R.H. (to Jersey Nuclear-Avco Isotopes, Inc., Bellevue, Wash. (USA)). French Patent 2,216,003/A/. 16 Nov 1973. 21p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 02 Feb 1973, USA.

The invention concerns isotopic separation or enrichment from a medium containing several isotopes, especially those of uranium. Separation or enrichment is obtained by the use of an apparatus in which the isotope $U^{235}$ undergoes a gradual three-stage ionisation and is then separated from the isotope $U^{238}$ by crossed-field magnetohydrodynamic acceleration techniques. The separation or enrichment yield is improved by the use of three stages for the ionisation of the isotope $U^{235}$.

**4563 Process and apparatus for the separation of an isotope such as the $^{235}U$ isotope.** Levy, R.H.; Janes, G.S. (to Jersey Nuclear-Avco Isotopes, Inc., Bellevue, Wash. (USA)). French Patent 2,216,005/A/. 16 Nov 1973. 17p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 2 Feb 1973, USA.

A process and an apparatus to separate one isotope from an environment consisting of several isotopes are described. The process is defined by the production, from a substance made up of isotopes, of a vapour which expands radially to pass between plates collecting the isotope required and a plate collecting the other isotopes, the required isotope being excited then ionised without ionisation of the others. The process is particularly suitable for the separation of the isotope $U^{235}$ from other uranium isotopes, especially $U^{238}$.

**4564 Isotope separation process.** Petschek, Harry. (to Jersey Nuclear-Avco Isotopes, Inc., Bellevue, Wash. (USA)). French Patent 2,216,004/A/. 16 Nov 1973. 18p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 02 Feb 1973, USA.

The invention relates to isotopic separation or enrichment. Isotopes are separated or enriched by the use of an apparatus designed for the gradual selective ionisation of one isotope present in a medium containing several. The process and apparatus described can be used especially to separate the isotope $U^{235}$ or to improve its enrichment yield.

**4565 Method and device for selectively exciting an isotope of a medium comprising several isotopes.** Janes, G.S.; Levy, R.H. (to Jersey Nuclear-Avco Isotopes, Inc., Bellevue, Wash. (USA)). French Patent 2,232,354/A/. 7 Jun 1974. 17p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 8 Jun 1973, USA.

The method according to the invention comprises the step of exciting the isotope of the desired type, in a medium comprising isotopes of various types, from the ground state or from low-level states (e.g. thermally excited states) to a level of intermediate energy through transition steps, followed by the ionizing excitation through a transition step above the ionization level, without exciting the isotopes of other types of the medium, so as to separate the ionized isotope of the first type. Such a method is suitable, in particular for separating the isotope $U^{235}$.

**4566 Method for separating gaseous mixtures of isotopes.** Neimann, H.J.; Schuster, E.; Kersting, A. (to Kraftwerk Union Aktiengesellschaft). US Patent 3,969,204. 13 Jul 1976. Priority date 14 Jun 1974, German, Federal Republic of (F.R. Germany). 4p.

A gaseous mixture of isotopes is separated by laser excitation of the isotope mixture with a narrow band of wavelengths, molecularly exciting mainly the isotope to be separated and thereby promoting its reaction with its chemical partner which is excited in a separate chamber. The excited isotopes and the chemical partner are mixed, perhaps in a reaction chamber to which the two excited components are conducted by very short conduits. The improvement of this method is the physical separation of the isotope mixture and its partner during excitation. The reaction between HCl and the mixture of $^{235}UF_6$ and $^{238}UF_6$ is discussed. (DDA)

## FUELS PRODUCTION AND PROPERTIES

*REFER ALSO TO CITATION(S) 4556, 4576, 5014, 5422*

**4567 (ORNL/MIT—210) Determination of $^{232}U$ daughter products released from HTGR fuel during refabrication. Part 2.** Bencini-Tibo, L.F.; Horton, J.R.; Kelley, D.F. (Massachusetts Inst. of Tech., Oak Ridge, Tenn. (USA). School of Chemical Engineering Practice). 21 Mar 1975. Contract W-7405-eng-26. 31p. Dep. NTIS $4.00.

During the heat treatment step of High Temperature Gas-Cooled Reactor (HTGR) fuel beads, the $^{233}U$-loaded fuel beads are exposed to temperatures as high as 1700°C. Since $^{233}U$ fuel beads unavoidably contain a small percentage of $^{232}U$, decay products of $^{232}U$ might be released during the heat treatment step. To avoid shielding requirements, experiments were conducted using $^{232}Th$-loaded fuel beads rather than $^{233}U$-loaded fuel beads. Decay products of $^{232}U$ and $^{232}Th$ are the same after $^{228}Th$. Experimental data were obtained by monitoring the 583 and 2614 keV gamma emissions of $^{208}Tl$. Computer simulations of the decay process and experimental data were used to infer what relative amount of the daughter products was removed. The carbonization step (300 to 500°C) has an effect on the loss of daughter products in the conversion step. Using uncarbonized fuel beads, approximately 50 percent of $^{220}Rn$ was removed at 300°C and approximately 20 percent of $^{220}Rn$ was removed at 200°C. At most, 5 percent of $^{220}Rn$ was removed from uncarbonized beads at 25°C. Marginal $^{220}Rn$ loss was detected at 100°C using pre-carbonized beads. At 1400°C, 92 percent $^{212}Pb$, 70 to 90 percent $^{212}Bi$, and 0 percent $^{224}Ra$ losses were observed. At 1600°C, 100 percent $^{212}Pb$, 80 to 100 percent $^{212}Bi$, and 3 to 7 percent $^{224}Ra$ losses were observed. At 1750°C, 100 percent $^{212}Pb$, 80 to 100 percent $^{212}Bi$, and 62 percent $^{224}Ra$ losses were observed. At 1800°C, 100 percent $^{212}Pb$, 80 to 100 percent $^{212}Bi$, and 86 percent $^{224}Ra$ losses were observed.

**4568 Mathematical simulation of the extractive reprocessing of nuclear fuel. III. Redox reextraction using iron salts.** Rozen, A.M.; Zel'venskii, M.Ya.; Shilin, I.V. *Sov. At. Energy (Engl. Transl.)*; **38**: No. 6, 473-478(Jun 1975).

The aim of the present investigation was to develop a mathematical model and a computing algorithm for the redox reextraction of neptunium and plutonium with due allowance for the kinetics of the chemical reactions in the aqueous phase, and also to analyze the influence of the basic parameters of the process on its efficiency, leading to a rational choice of the optimum conditions of operation taking the $Fe^{2+}$-$Fe^{3+}$ system as redox reagent. The algorithm developed in this connection is of a general character, and may be used for processes involving other nonextracted redox reagents. 9 refs.

**4569 Performance of nuclear fuel elements in the CEGB magnox reactors: results of post irradiation examination studies.** Harris, J.E. (Central Electricity Generating Board, Gloucestershire, Eng.). pp 45-57 of In Microstructural science. Vol. 4. Filer, E.W. (ed.). New York; Elsevier Publishing Co., Inc. (1976).

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

See CONF-750774—.

The Central Electricity Generating Board is charged with the responsibility for producing all the electrical power for England and Wales. About 10 percent of the power generated is derived from 16 Magnox (gas cooled) reactors at eight sites, mostly around the coast. At any one time more than half a million fuel elements are being irradiated and about 1 percent of these are examined in the shielded facilities at the Berkeley Nuclear Laboratories of the CEGB or the Windscale Laboratories of the United Kingdom Atomic Energy Authority. This collaborative monitoring programme represents the most comprehensive and prolonged fuel element technical surveillance undertaken in support of a reactor system. A significant part of the post irradiation studies involves detailed metallography of sections from the fuel elements and extensive shielded microscope facilities have been constructed and are in operation. Results of this monitoring program are described and attention is drawn to the value of microstructural studies in elucidating the mechanisms of fuel element deformation and failure. The relationship of this work to the fundamental back-up research is described and the practical consequences of the studies are highlighted. 12 fig.

**4570 Radiation from $^{232}U$ in recycle fuel fabrication.** Uotinen, V.O.; Schwenk, G.A. (Babcock and Wilcox Co., Lynchburg, VA). *Trans. Am. Nucl. Soc.*; **23**: 266-267(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## SPENT FUELS REPROCESSING

*REFER ALSO TO CITATION(S) 4584, 4588, 4589, 4591, 4592, 4605, 4893, 4939, 5010*

**4571** (HW—74792) **Z Plant Filtrate Ion Exchange Facility (CGC-978) start-up slowsheep.** Berglund, C.J. (General Electric Co., Richland, Wash. (USA). Hanford Atomic Products Operation). 31 Aug 1962. Contract E(45-1)-1350. 3p. Dep. NTIS $3.50. Declassified 25 Jul 1972.

A flowsheet representing start-up conditions of the Filtrate Ion Exchange Facility is given. These flowsheet conditions are used for the routine recovery of plutonium from oxalate precipitation filtrates. (LK)

**4572** (ORNL/TM—5556) **LMFBR Fuel Reprocessing Program progress report for period April 1 to June 30, 1976.** Burch, W.D.; Feldman, M.J.; Groenier, W.S.; Vondra, B.L. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 70p. AT.

The program is aimed at providing the technology for the design of commercial reprocessing facilities that will be required by the late 1990s. The process and equipment development phase should culminate in a hot pilot-plant process demonstration in 1985-90 for the feed from FFTF and CRBR. Criteria were developed for this hot pilot plant. Laboratory and hot-cell studies included the study of base metal zeolites for $I_2$ trapping, dissolution of $PuO_2$ in HI, solubilities of $PdI_2$, and fixation of iodine waste in concrete. Engineering research studies are being conducted on voloxidation, dissolution, feed preparation (nitrogen oxide scrubbing), fluorocarbon absorption, reliability, Iodox process, and instrumentation and control systems. Component testing was also conducted. The status of the Integrated Prototype Equipment Test Facility is reported. (DLC)

**4573 Destructive effect of hydrogen on the cladding during reprocessing of the fuel elements of a water-cooled/water-moderated power reactor.** Ageenkov, A.T.; Savel'ev, V.F. *Sov. At. Energy (Engl. Transl.);* **37**: No. 1, 737(Jul 1974).

Investigation of the damaging effect of hydrogen on zirconium alloy claddings during fuel element reprocessing was carried out showing that accelerated interaction of the alloys with hydrogen begins at 600°C, between 700-800°C the hydrogen content reaches critical values 1.7-2.0 wt% in one hour.

**4574** (ORNL-tr—4208) **Concept of a large-capacity irradiated-fuel-reprocessing plant.** Buck, C.; Couture, J.; Issel, W.; Mamelle, J. (United Reprocessors G.m.b.H., Karlsruhe (Germany, F.R.); Saint-Gobain - Techniques Nouvelles, 92 - Courbevoie (France)). 1975. Translated by M. Gerrard from French. (CONF-750411—93). 18p. Dep. NTIS $3.50.

From European nuclear conference; Paris, France (21 Apr 1975).

The processing of LWR fuels in recent years has run into difficulties due to the adaptation of the Purex process to these fuels with a high irradiation rate. This has led to development of new technological techniques. High-capacity plants should, in the future, limit their discharge of liquid and gaseous effluents to values comparable to those of nuclear electric stations. Investment costs necessary for processing the effluents and for temporary storage of the wastes are part of the total cost of these plants. However, the investments remain within acceptable limits. The 1500-ton/year plant presented is an example of what can be done in the 1980's. (DLC)

**4575 $UF_6$ conversion of uranyl nitrate from spent fuel reprocessing.** Cahen, M. (Societe pour la Conversion de l'Uranium en Metal et Hexafluorure (COMURHEX), 26 - Pierrelatte (France)). *Nucl. Eng. Int.;* **20**: No. 236, 954-956(Nov 1975).

The new COMURHEX process at Pierrelatte for the conversion of uranyl nitrate to $UF_6$ from the slightly enriched uranium in the spent fuel from light water reactors is described. The uranium is precipitated as ammonium diuranate which is calcined and reduced to $UO_2$ in a special rotary kiln. $UO_2$ is hydrofluorinated in a moving bed reactor, and the $UF_4$ converted to $UF_6$ by direct reaction with fluorine gas in a flame reactor. Purification is by a series of complimentary operations based on the differing volatilities and chemical properties of the contaminant fluorides. Nonvolatile contaminant fluorides are removed by filtration which eliminates $\beta$ and $\gamma$ contaminants, the $\alpha$ being removed by means of a sorption tower. The facility is preparing to operate at the rate of output required for 1976.

**4576 HTGR fuel cycle.** Takashima, Y.; Hirata, A. (Tokyo Inst. of Tech.). *Nenryo Kyokai-shi;* **54**: No. 584, 965-971(Dec 1975). (In Japanese).

High temperature gas cooled reactor (HTGR), fueled with fully enriched uranium and thorium, is expected to show a better fuel performance and will reduce the consumption of uranium resources to a large extent. The best use of thorium and bred fuel, uranium-233, can be achieved by the coated particle fuel, as the contamination of recovered U-233 with U-236 and U-238 is limited to a low level while uranium particles and thorium particles are homogeneously mixed in a fuel rod. The unique feature of HTGR fuel structure requires a modernization of spent-fuel reprocessing techniques. Crush-burn-leach and offgas treatment techniques are being developed in the U.S. under a government sponsored program. Tritium and noble gases can be removed efficiently through such techniques. From the environmental safety standpoint, this is an important advantage for the HTGR fuel reprocessing. 3 refs.

**4577 Effects of impurities on $PuO_2$ dissolution in nitric—hydrofluoric acid solutions.** Tallent, O.K.; Mailen, J.C. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.;* **23**: 261(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## MARKETING AND ECONOMICS

*REFER ALSO TO CITATION(S) 4941, 4942*

## WASTE MANAGEMENT

*REFER ALSO TO CITATION(S) 5192, 6087*

**4578** (ARH-CD—692) **Freeze block testing of buried waste lines.** Robbins, E.D.; Willi, J.C. (Atlantic Richfield Hanford Co., Richland, Wash. (USA)). 20 May 1976. Contract E(45-1)-2130. 28p. Dep. NTIS $4.00.

An investigation was conducted to demonstrate application of freeze blocking in waste transfer lines such that a hydrostatic pressure test can be applied. A shop test was conducted on a 20-foot length, 3-inch schedule 40, carbon steel pipe using a coolant of dry ice and Freon. The positive results from these tests prompted a similar employment of the freeze block method in hydrostatic pressure testing the feed inlet leading to 241-S-101 Waste Tank. This pipeline is a 3-inch schedule 10, stainless steel pipe approximately 800 feet long. The freeze block was formed near the lower end of the pipe as it entered the 101-S Waste Tank and a pressure hold test was applied to this pipeline. This test proved the integrity of the pipeline in question, and demonstrated the validity of freeze blocking an open-ended pipeline which could not be hydrotested in other conventional ways. The field demonstration facility, costing $30,200 was completed late in 1975.

**4579 Nuclear waste problem in perspective.** Puechl, K.H. *Nucl. Eng. Int.;* **20**: No. 236, 950-954(Nov 1975).

A quantitative assessment of radioactivity levels in nuclear waste is presented and a novel method is suggested for waste treatment based on the philosphy of keeping radioactive waste in as low a concentrated form as is practicable. This introductory presentation is aimed at gaining insight rather than absolute accuracy. Simplistic models are therefore used and numerical accuracy is sacrificed for clarity. In the context of the discussion, factors of 2 are of no significance and even a factor of 10 discrepancy is acceptable if neglect of detail does not affect conclusions and gives assurance of better understanding.

**4580 Evaluation of the TRU waste problem in the commercial nuclear industry.** Dunne, J.F.; O'Hara, F.A. (Ohio State Univ., Columbus). *Trans. Am. Nucl. Soc.;* **23**: 262(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

### WASTE PROCESSING

*REFER ALSO TO CITATION(S) 4549, 5445*

**4581** (ARH-ST—135) **Conversion of Hanford salt cake to glass: laboratory studies.** Schulz, W.W.; Dressen, A.L.; Hobbick, C.W.; Kupfer, M.J. (Atlantic Richfield Hanford Co., Richland, Wash. (USA)). May 1976. Contract E(45-1)-2130. 51p. Dep. NTIS $4.50.

Approximately 140 million liters of solid salt cake (mainly $NaNO_3$), produced by evaporation of aged, alkaline high-level wastes, will be stored in underground tanks when the present Hanford Waste Management Program is completed in the early 1980's. These solid wastes can be converted to silicate-based glasses by melting them either at 1200 to 1300°C with appropriate amounts of sand and lime (soda-lime formulation) or at 1000 to 1100°C with appropriate amounts of Columbia River basalt and $B_2O_3$ (basalt formulation). Both formulations yield dense, immobile glasses of low water leachability ($10^{-7}$ to $10^{-6}$ g $cm^{-2}$ $day^{-1}$) suitable for terminal storage. The soda-lime formulation is presently preferred over the basalt formulation because it can accommodate more salt cake (50 wt percent versus 30 to 40 wt percent) while yielding a glass whose volume is 10 to 20 percent less than the volume of the salt cake in the melt charge.

**4582** (CONF-760822—18) **Release of adsorbed krypton and xenon from spilled charcoal.** Underhill, D.W. (Harvard Univ., Boston, Mass. (USA). Harvard Air Cleaning Lab.). 1976. 6p. Harvard Air Cleaning Lab., Boston, MA.

From 14. US ERDA air cleaning conference; Sun Valley, Idaho, United States of America (USA) (2 Aug 1976).

The rate of release of the fission gases, krypton, and xenon, depends on the depth of the spilled charcoal, the decay constant of the fission gas, and the initial distribution of fission gas within the spilled charcoal. A mathematical analysis of the rate of release is presented here which takes into account the initial distributions which may be encountered in practice. It is found that: (1) fission gases more than 15 cm from the surface generally decay within the charcoal before diffusing to the surface; (2) xenon isotopes diffuse relatively slowly and that the release of xenon can be protracted over several days and (3) the initial distribution has a strong effect on both the rate of release and the fraction of fission gas released. These equations can be applied to the release of fission gases from a charcoal adsorption bed following rupture (as for example by an earthquake). It is suggested that in order to minimize the possible release of fission gases during such an incident that during normal operation a charcoal adsorption bed be operated at a flow rate above a certain minimum for this would prevent the adsorbed fission gases from being contained within a shallow area from which their release could be relatively rapid.

**4583** (CONF-760822—19) **Particulate collection in a low level radioactive waste incinerator.** Rudnick, S.N.; Leith, D.; First, M.W. (Harvard Univ., Boston, Mass. (USA). Harvard Air Cleaning Lab.). 1976. 21p. Harvard Air Cleaning Lab., Boston, MA.

From 14. US ERDA air cleaning conference; Sun Valley, Idaho, United States of America (USA) (2 Aug 1976).

As designed, sintered stainless steel filters will clean the gas from the secondary cyclone at a low level radioactive waste incinerator. Bench-scale apparatus was used to evaluate asbestos floats and diatomaceous earth as filter aids to prevent clogging of the sintered metal interstices and to decrease filter penetration. Both precoats prevented irreversible pressure drop increase, and decreased cold DOP penetration from 80 percent to less than 1 percent. Less diatomaceous earth was needed than asbestos floats, to collect the same quantity of fly ash. A back-up study evaluated a moving bed of sodium carbonate pellets in lieu of the sintered metal filters. Since identical sodium carbonate pellets are used to neutralize hydrogen chloride in the incinerator, their use in a moving bed has the advantages of trouble free disposal and cost free replacement. Co$^-$, counter, and cross-current beds were studied and gave fly ash penetrations less than 0.1 percent at moderate pressure drop. The filter cake which forms on the pellet surfaces decreases penetration greatly.

**4584** (CONF-760826—8) **Recovery of americium and curium from nuclear fuel processing waste solutions.** Campbell, D.O.; Buxton, S.R. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-eng-26. 28p. Dep. NTIS $4.00.

From American Chemical Society meeting; San Francisco, California, United States of America (USA) (29 Aug 1976).

Am and Cm exist in the trivalent state under conditions practical in reprocessing, and their chemistry is very similar to that of the rare earths which are present in relatively large amount as major fission products. Conceptual processes to recover Am and Cm, therefore, usually include two separate cycles. The first is the recovery of Am, Cm, and any transcurium actinides, along with the lanthanides, but hopefully separated from all the rest of the fission products and bulk chemicals used in processing, like sodium nitrate, iron, and sulfate. The second cycle is the partition of Am, Cm, and possibly heavier actinides like Cf, from the fission product rare earths. The first cycle, co-recovery of lanthanides and actinides, can, in principle, be accomplished by several methods including precipitation, solvent extraction, and ion exchange. Each has its own problems and limitations, as well as different interactions with the second cycle. The methods of cation exchange and oxalate precipitation are discussed.

**4585** (CONF-761014—2) **Oak Ridge waste management programs: geologic isolation and actinide partitioning.** Blomeke, J.O.; McClain, W.C. (Oak Ridge National Lab., Tenn. (USA); Union Carbide Corp., Oak Ridge, Tenn. (USA). Nuclear Div.). 1976. Contract W-7405-ENG-26. 22p. Dep. NTIS $3.50.

From 1. Pacific Basin topical conference on nuclear development and the fuel cycle; Honolulu, Hawaii, United States of America (USA) (11 Oct 1976).

The scope and objectives of the geologic isolation and actinide partitioning programs at Oak Ridge are summarized. The principal elements and schedules for each are given. (LK)

**4586** (DPST—76-125-1) **Savannah River Laboratory quarterly report: waste management, January—March 1976.** (Du Pont de Nemours (E.I.) and Co., Aiken, S.C. (USA). Savannah River Lab.). Jul 1976. Contract E(07-2)-1. 19p. Dep. NTIS $3.50.

The conceptual process for solidification of Savannah River Plant liquid wastes to glass monoliths was improved to use spray dryers discharging directly to ceramic continuous melters, instead of batch-blending dry sludge powder with glass-forming frit for in-can melting. Calculations indicate that the centerline temperature of concrete waste forms air-cooled by natural convection would not exceed 130°C during normal storage conditions in the conceptual Retrievable Storage Facility. A program to compute radial heat flow from a solid cylinder during an exothermic chemical reaction has been developed and applied to the hydration of the "Lumnite" cement proposed for fixation of high-activity plant waste. Final scale-up tests of the ion-exchange process for removing $^{137}Cs$ from waste supernate showed that changes in the column aspect ratio (length/diameter) do not significantly affect cesium removal. Laboratory tests show that the volume of neutralized solids from the five largest plant waste streams can be reduced approximately 30 percent by total denitration of free nitric acid and partial denitration of metal nitrates with formic acid.

**4587** (HEDL-TME—76-22) **Nuclear fuel cycle and production programs. Progress report for July—December 1975.** Cooley, C.R.; Lerch, R.E. (Hanford Engineering Development Lab., Richland, Wash. (USA)). May 1976. Contract E(45-1)-2170. 70p. Dep. NTIS $5.00.

This is the sixth progress report on Nuclear Fuel Cycle and Production programs being conducted at HEDL for ERDA. Progress is reported on the Commercial Alpha Waste and Chemical Processing of Combustible Solid Wastes (Acid Digestion) programs. Data on commercial burial of radioactive wastes, operational data on the Acid Digestion Test Unit (ADTU), and the design basis for an acid digestion unit for treating radioactive wastes are also discussed.

**4588** (ICP—1099) **Waste management development technology progress for April—June 1976.** (Idaho National Engineering Lab., Idaho Falls (USA)). Aug 1976. Contract E(10-1)-1375-S-72-1. 24p. Dep. NTIS $4.00.

Progress is reported on development programs in the management of radioactive waste from spent nuclear fuel reprocessing. Studies are reported on ERDA wastes generated at the Idaho Chemical Processing Plant and on simulated wastes from commercial LWR fuel reprocessing plants. Technology under development includes fluidized-bed calcination of high-level liquid wastes, post-calcination treatment of solidified wastes, retrievability of stored calcined waste, adsorption of iodine from airborne effluents, and long-term storage of zeolite-encapsulated and pressure-cylinder-contained fission product noble gases.

**4589** (ORNL/TM—5457) **Computer model for the KALC process studies in the ORGDP Off-Gas Decontamination Pilot Plant.** Glass, R.W.; Barker, R.E. (Oak Ridge National Lab., Tenn. (USA)). Sep 1976. Contract W-7405-eng-26. 49p. Dep. NTIS $4.50.

A computer model of the KALC process is presented for the equipment configuration in use during HTGR off-gas studies at the ORGDP Off-Gas Decontamination Pilot Plant. The model is tailored to require input routinely available during such experimental studies. A program is included to provide McCabe-Thiele plots as an additional convenience.

**4590** (BNWL-tr—203) **Embedding of radioactive wastes by thermosetting resins.** Baer, A.; Traxler, A.; Limongi, A.; Thiery, D. (Groupement pour les Activites Atomiques et Avancees (GAAA), 92 - Le Plessis-Robinson (France); CEA Centre d'Etudes Nucleaires de Grenoble, 38 (France). Service de Protection et des Etudes d'Environnement). 1976. Translation of IAEA-SM—207/32. (CONF-760310—17). 34p. Dep. NTIS $4.00.

From IAEA symposium on the management of radioactive waste; Vienna, Austria (22 Mar 1976).

The process for embedding radioactive wastes in thermosetting resins perfected and applied at the Grenoble Nuclear

Research Center and its application to the treatment of radioactive wastes from Light-Water Nuclear Power Plants (PWR and BWR) are presented. The various types of wastes are enumerated and their activities and quantities are estimated: evaporator concentrates, ion exchange resins, filtration sludges, filters, various solid wastes, etc. The authors review the orientations of the research performed and indicate, for each type of waste considered, the cycle of treatment operations from rendering the radioelements insoluble to drying the concentrates to final embedding. The operational safety of the process and the safety of transport and storage of the embedded wastes are investigated. The essential technical features concerning the safety of the installation and of the final product obtained are presented. In particular, results are presented from tests of resistance to fire, irradiation, leaching, etc., these being characteristics which represent safety criteria. The economic aspects of the process are considered by presenting the influences of the reduction of volume and weight of wastes to be stored, simplicity of installations and cost of primary materials.

**4591 Removal of iodine from reactor fuel solutions as insoluble $PdI_2$.** Mailen, J.C.; Horner, D.E. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.*; **23**: 260(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4592 Removal of radioiodine from gas streams by electrolytic scrubbing.** Horner, D.E.; Mailen, J.C. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.*; **23**: 260-261(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4593 Iodine decontamination factor for liquid radioactive waste volume reduction system.** Tokerud, L.D.; Garcia, R. (Aerojet Energy Conversion Co., Sacramento, CA). *Trans. Am. Nucl. Soc.*; **23**: 264(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4594 Immobilization of $^{129}I$ as barium iodate with Portland cement.** Clark, W.E. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.*; **23**: 264-265(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4595 Method and apparatus for treating waste gases containing radioactive impurities, particularly krypton and xenon nuclides.** Stumpf, W.; Queiser, H.; Juentgen, H.; Schroeter, H.J.; Knoblauch, K. (to Licentia Patent-Verwaltungs GmbH). US Patent 3,963,460. 15 Jun 1976. Priority date 4 Apr 1973, German, Federal Republic of (F.R. Germany). 20p.

A method is described for treating waste gases containing radioactive contamination, particularly krypton and xenon nuclides. The waste gas stream to be decontaminated is initially conducted through an enrichment system wherein the waste gas stream is divided into at least two partial streams one of which is substantially free from the radioactive impurities and constitutes the poor gas fraction and another of which constitutes the rich gas fraction. The poor gas fraction is discharged, at least in part into the atmosphere while the rich gas fraction is fed into an activated carbon delay path whose output is discharged, either directly or indirectly into the atmosphere. Apparatus for carrying out the method is also disclosed.

## WASTE DISPOSAL AND STORAGE

*REFER ALSO TO CITATION(S) 4581, 4585, 4586, 4587, 4605, 4939, 5117, 5262*

**4596 (ANL—76-82) Analysis of factors influencing the reliability of retrievable storage canisters for containment of solid high-level radioactive waste.** Mecham, W.J.; Seefeldt, W.B.; Steindler, M.J. (Argonne National Lab., Ill. (USA)). Aug 1976. Contract W-31-109-Eng-38. 120p. Dep. NTIS $6.00.

The reliability of stainless steel type 304L canisters for the containment of solidified high-level radioactive wastes in the glass and calcine forms was studied. A reference system, drawn largely from information furnished by Battelle Northwest Laboratories and Atlantic Richfield Hanford Company is described. Operations include filling the canister with the appropriate waste form, interim storage at a reprocessing plant, shipment in water to a Retrievable Surface Storage Facility (RSSF), interim storage at the RSSF, and shipment to a final disposal facility. The properties of stainless steel type 304L, fission product oxides, calcine, and glass were reviewed, and mechanisms of corrosion were identified and studied. The modes of corrosion important for reliability were stress-corrosion cracking, internal pressurization of the canister by residual impurities present, intergranular attack at the waste-canister interface, and potential local effects due to migration of fission products. The key role of temperature control throughout canister lifetime is considered together with interactive effects. Methods of ameliorating adverse effects and ensuring high reliability are identified and described. Conclusions and recommendations are presented.

**4597 (BNWL—2035) Experimental design for demonstration of bio-barriers placed in a simulated burial trench.** Cline, J.F.; Holter, G.M.; Rickard, W.H.; Klepper, E.L. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). May 1976. Contract E(45-1)-1830. 18p. Dep. NTIS $3.50.

Studies which have been undertaken to improve burial techniques to prevent the intrusion of buried wastes by plants and animals are described. The study consists of two parts. The first part is a demonstration trench in which a layer of cobble has been placed over simulated wastes and covered with a deep layer of topsoil. The second part is an experiment in which several different kinds of biological barriers are tested in a replicated plot design. The "simulated wastes" consist of soil mixed with lithium chloride, which is biologically available and can be easily detected by spectrophotometric analysis. The purpose of the study is to evaluate the effectiveness of these barriers to biological invasion of buried wastes.

**4598 (ORNL—5142) Development of cementitious grouts for the incorporation of radioactive wastes. Part 2. Continuation of cesium and strontium leach studies.** Moore, J.G. (Oak Ridge National Lab., Tenn. (USA)). Sep 1976. Contract W-7405-eng-26. 144p. Dep. NTIS $6.75.

Additional leach studies were completed on the leachability of cesium and strontium from simulated hydrofracture grout. These studies followed the test method proposed by IAEA or a modification which exposed smaller specimens with a higher surface-to-volume ratio to a larger volume of leachant. Results showed that the amount of cesium or strontium leached from the grout varied directly with the degree of drying during curing and inversely with the time of curing. The leachability also depends on the composition of the leachant and varies in the order: distilled water greater than tap water greater than grout water. The total waste concentration had little effect on the leachability of either cesium or strontium. The credibility of the laboratory results was substantiated by a short-term continuous leach test made on a fragment of a core sample of actual hydrofracture grout. The modified effective diffusivities ($10^{-11}$ to $10^{-10}$ $cm^2/s$) calculated from these limited data were comparable to those obtained from laboratory studies containing Grundite clay. These tests also confirmed the effect of various clays on the leachability of cesium and the importance of leachant renewal frequency on the leach rate.

**4599 (ORNL-tr—4090(DRAFT)) Very-long-term storage of fission products.** Sousselier, Y.; Pradel, J.; Cousin, O. (CEA Centre d'Etudes Nucleaires de Fontenay-aux-Roses, 92 (France)). 1976. Translated by M. Gerrard from French. 15p. Dep. NTIS $3.50.

The large majority of the fission products, with 99.9 percent of the radioactivity content, do not pose actual problems in storage in a geological formation for which we can guarantee total confinement. Safety of storage in a geological formation for the radionuclides of long half-life is based in particular on the absorption capacity of the geological formations and the example of the Oklo fossil reactor and the retention of Pu which is produced is a striking example. But the problems are not the same, and the properties that we look for in the terrain are not the same. We could thus be led to storage in different geological formations for the fission products and the long-half-life emitters. Their separation is interesting from this point of view, but the date at which the separation is made will not be necessarily that of reprocessing. But there is a question of one or the other, and these storages will offer a very high level of insurance and will present only the potential hazards that are very comparable with those presented by natural conditions.

**4600 Analysis of actinide depletions and radiotoxic hazards following irradiation in a fusion—fission hybrid reactor.** Chi, J.W.H.; Kellman, S.; Klein, D.; Rose, R.P. (Westinghouse Electric Corp., Pittsburgh). *Trans. Am. Nucl. Soc.*; **23**: 262-263(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4601 Plutonium burnout in fast reactors as a waste management alternative.** Beaman, S.L.; Bailey, H.S. (General Electric Co., Sunnyvale, CA). *Trans. Am. Nucl. Soc.*; **23**: 263-264(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4602 Borehole plugging by melted in-situ rocksalt.** Black, D.L.; Fernandes, R. (Westinghouse Astronuclear Lab., Pittsburgh). *Trans. Am. Nucl. Soc.*; **23**: 265(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4603 Method and apparatus for the purification of a liquid contaminated with radioactive substances.** Mende, H. (to Lawa AG). US Patent 3,969,194. 13 Jul 1976. Priority date 30 Oct 1973, Switzerland. 8p.

A method of and apparatus for the purification of a liquid contaminated with radioactive substances is described, wherein the liquid is infed to an evaporator in or with which there is connected a column having a multiplicity of superposed plates or floors. The vapor generated in the evaporator is guided through a washing or scrubbing liquid uniformly distributed at the floors and flowing in crosswise counterflow with regard to the vapor. The washing liquid at the floors is deflected a number of times in such a manner that the washing liquid itself together with the droplets entrained by the vapor are uniformly admixed and the washing liquid subjected to a constant intake of the radioactive substance.

## ENVIRONMENTAL ASPECTS

*REFER ALSO TO CITATION(S) 4604, 4929, 5680*

## HEALTH AND SAFETY

*REFER ALSO TO CITATION(S) 4559, 5680, 5764*

**4604 Protection against radiation in the mining and processing of uranium ores.** Pradel, J.; Zettwoog, P. *Ind. Miner., Mine;* No. 4, 417-421(1975). (In French).

The authors review the major radiation problems associated with the mining and processing of uranium ores. External radiation, radon (the rare gas that escapes from the ore), and the radioactivity of ore dust and waste water are discussed in detail. The effects of radiation on both the miners and the nearby population are examined. Measures taken in France to ensure protection against radiation are also discussed. 7 refs.

## REGULATIONS

**4605 Design objectives for highly radioactive solid material handling and storage facilities in a reprocessing plant.** *Annu. Book ASTM Stand.*; No. 305, 15p(1975).

This standard sets forth design objectives related to facilities for the handling and storage of highly radioactive materials in solid form. This standard presents the minimum design objectives of facilities for the handling and storage of spent fuel. It contains requirements for the design of the spent-fuel storage pool, including spent-fuel storage racks, pool makeup and cleanup systems, pool structure and integrity, radiation shielding, residual-heat-removal and radiation-monitoring systems; of the cask loading area, including requirements for the handling and decontamination of the shipping casks; and of the building, including requirements for ventilation, confinement, and fire protection.

### ACCOUNTABILITY AND SAFEGUARDS

*REFER ALSO TO CITATION(S) 5191*

**4606 (BNWL—2082) PNL nuclear materials safeguards studies, 1968—1975.** Christopherson, E. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). Sep 1976. Contract E(45-1)-1830. 31p. Dep. NTIS $4.00.

Nuclear materials safeguards studies sponsored at Pacific Northwest Laboratory since 1968 are summarized. The scope of the studies includes an investigation of the sources of error in MUF uncertainty, in the disparity between shipper and receiver measurements, and in inventory verification. Primary and secondary verification points have been differentiated, with emphasis on the additional measurements necessary to verify both inventories and flows. Studies also address the problems of verifying the plutonium input to the fuel cycle and determining the composition of various types of measurement bias. The studies' findings are organized in two groups: those associated with the operator (contractor or licensee) and those associated with an agency (ERDA, Nuclear Regulatory Commission (NRC), or International Atomic Energy Agency (IAEA)). Numbers in parentheses refer to report sections discussing the particular contributions. Within the two groups, the findings appear in the same order as they appear in the main text. The featured contributions are intended to be key points of interest to those in ERDA directly concerned with safeguards inspection.

**4607 (COM—75-11017/1ST) Tamper-resistant television surveillance system. Final report.** Laug, O.B.; Yee, K.W. (National Bureau of Standards, Washington, D.C. (USA)). May 1975. Contract ACDA/RA-126. 39p. (NBSIR—75-707). NTIS $3.75.

The report describes a tamper-resistant television system. This system will be part of a larger system used for verifying compliance with certain international arms control or safeguard agreements. This work is part of a joint U.S.-Canada safeguards research program to develop and evaluate tamper-resistant, tamper-indicating techniques and instrumentation that might be applicable in safeguarding reactors or other nuclear facilities. The principal design objectives are to provide a system capable of unattended operation, data storage capacity for a period up to 90 days, and resistance to deception by insertion of false video information on the transmission line or substitution of false scenes in the camera's field of view. These objectives are accomplished by utilizing commercial high-resolution closed-circuit TV and photography coupled with a video encoding technique which permutes the luminance signal in a different pattern for each recorded picture. (GRA)

**4608 International symposium on the safeguarding of nuclear material sponsored by the International Atomic Energy Agency, Vienna, 20-24 October 1975.** *Nucl. Eng. Int.*; **20**: No. 237, 1021-1024(Dec 1975).

A review is presented of the IAEA symposium held in Vienna, October, 1975. The topics discussed included: IAEA proposals for updating and improving the effectiveness of its safeguard systems and some of the problems encountered in implementing its policies; evaluation of risk and the use of risk analysis to develop advanced systems of physical protection; safeguard systems in the EEC and in the USA; and developments in instrumentation for materials control.

**4609 Safeguarding nuclear material.** Curry, R.V. (Nuclear Fuel Services, Rockville, MD). *Trans. Am. Nucl. Soc.*; **23**: 243-244(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4610 Comparison of several Kalman filter models for establishing MUF.** Pike, D.H. (Univ. of Tennessee, Knoxville); Morrison, G.W.; Holland, C.W. *Trans. Am. Nucl. Soc.*; **23**: 267-268(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

### ADMINISTRATIVE AND REGULATORY

**4611 (REG/G—10.4(07-76)) Guide for the preparation of applications for licenses to process source material.** (Nuclear Regulatory Commission, Washington, D.C. (USA). Office of Standards Development). Jul 1976. 9p. NUREG.

This guide describes the information needed to evaluate an application for a specific license to process source materials. Examples are manufacture of depleted U and Th—Mg alloy products; shaping, grinding, and polishing of lenses containing Th; and the manufacture and distribution of other products containing source material. (DLC)

## FUSION FUELS

*REFER ALSO TO CITATION(S) 5505*

**4612 (CONF-750989—P4, pp IV.12-IV.21) Estimated values of some cryogenic properties of hydrogen isotopes.** Briggs, C.K.; Hickman, R.G.; Tsugawa, R.T.; Souers, P.C. (Univ. of California, Livermore). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The literature on cryogenic hydrogen isotopes from 4.2 to 25°K is reviewed for triple points, vapor pressures, liquid viscosities, surface tensions, and liquid and solid densities. Data are extrapolated to yield values for DT. Empirical equations are given for all isotopes for each property. At the estimated 19.71°K triple point of 1:1 D-T in $D_2$-DT-$T_2$ solution, the estimated properties are: vapor pressure, 19,420 Pa; viscosity 550 x $10^{-7}$ Pa.s; surface tension 4.23 x $10^{-3}$ N/m; liquid density, 0.0446 x $10^6$ mol/m$^3$; solid density, 0.051 x $10^6$ mol/m$^3$; and shrinkage upon freezing, -13 vol percent. At 4.2°K, estimated values are: vapor pressure, 2.4 x $10^{-10}$ Pa and solid density, 0.053 x $10^6$ mol/m$^3$.

**4613** (CONF-750989—P4, pp IV.68-IV.82) **Studies of helium distribution in metal tritides.** Bowman, R.C. Jr.; Attalla, A. (Monsanto Research Corp., Miamisburg, OH). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The distribution of helium ($^3$He) in LiT, $TiT_2$, and $UT_3$, which are regarded as representative metal tritides, was investigated using pulse nuclear magnetic resonance (NMR) techniques. Analyses of the NMR lineshapes and nuclear relaxation times indicate the $^3$He atoms are trapped in microscopic gas bubbles for each tritide. The effects of concentration and temperature on the $^3$He distributions were investigated as well.

**4614** (CONF-750989—P4, pp IV.22-IV.35) **Estimated $D_2$—DT—$T_2$ phase diagram in the three-phase region.** Souers, P.C.; Hickman, R.G.; Tsugawa, R.T. (Univ. of California, Livermore). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

A composite of experimental $eH_2$-$D_2$ phase-diagram data at the three-phase line is assembled from the literature. The phase diagram is a smooth cigar shape without a eutectic point, indicating complete miscibility of liquid and solid phases. Additional data is used to estimate the $D_2$-$T_2$, $D_2DT$, and DT-$T_2$ binary phase diagrams. These are assembled into the ternary $D_2$-DT-$T_2$ phase diagram. A surface representing the chemical equilibrium of the three species is added to the phase diagram. At chemical equilibrium, it is estimated that 50-50 liquid D-T at 19.7°K is in equilibrium with 42 mole percent T vapor and 54 percent T solid. Infrared spectroscopy is suggested as a means of component analysis of liquid and solid mixtures.

## SOURCES

**4615** (CONF-750989—P4, pp IV.144-IV.157) **Reaction rates and electrical resistivities of the hydrogen isotopes with, and their solubilities in, liquid lithium.** Pulham, R.J.; Adams, P.F.; Huberstey, P.; Parry, G.; Thunder, A.E. (Univ. of Nottingham, Eng.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The rate of reaction, k, of hydrogen and of deuterium with liquid lithium have been determined up to pressures of 20kNm$^{-2}$ and at temperatures between 230 and 270°C. The reaction is first order with an apparent activation energy of 52.8 and 55.2 kJmol$^{-1}$ for hydrogen and deuterium, respectively. The deuterium isotope effect, k/sub H/k/sub D/, decreases from 2.95 at 230 to 2.83 at 270°C. Tritium is predicted to react even more slowly than deuterium. The freezing point of lithium is depressed by 0.082 and 0.075°C, respectively, by dissolved hydride and deuteride giving eutectics at 0.016 mol percent H and 0.012 mol percent D in the metal-salt phase diagrams. The depression and eutectic concentration are expected to be less for tritium. The increase in the resistivity of liquid lithium caused by dissolved hydrogen isotopes is linear and relatively large, 5 x $10^{-8}$ Ωm (mol percent H or D)$^{-1}$. The solubility of lithium hydride and deuteride was determined from the marked change in resistivity on saturation. The liquidus of the metal-salt phase diagram rises steeply from the eutectic point to meet the two-immiscible liquid region. Tritium is expected to be less soluble than deuterium. The partial molar enthalpies of solution are 44.2 and 55.0 kJmol$^{-1}$ for hydrogen and deuterium, respectively. These values are used to calculate the solvation enthalpies of the isotope anions in the metal.

## TRANSPORT AND STORAGE

**4616** (CONF-750989—P4, pp IV.36-IV.52) **Uranium—tritium system: the storage of tritium.** Carlson, R.S. (Monsanto Research Corp., Miamisburg, OH). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The thermodynamics of the uranium-tritium system were determined over the pressure range of 2 x $10^{-4}$ to 20 atm from experimental composition-pressure-temperature data. Both enthalpy and entropy were shown to vary slightly with composition by analysis of van't Hoff plots for the U-D system and the U-T system. The evolution of helium-3 borne in the lattice of a fully tritiated sample of uranium was studied over a period of several months, and the relative proportion of helium-3 and tritium in the evolved gas from an aged $UT_3$ sample was determined at several temperatures. The desorption and absorption characteristics of a typical uranium-tritium storage bed have been studied and observed for several years.

**4617** (CONF-750989—P4, pp IV.53-IV.67) **Helium release from uranium tritide.** Malinowski, M.E.; Coronado, P.R. (Sandia Labs., Livermore, CA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The release of $^3$He from coarse (0.6 m$^2$/g) stoichiometric uranium tritide has been measured as a function of time up to a tritide age of 1200 days. Less than 2 percent release occurs until approximately 280 days, after which the release increases dramatically, with the $^3$He release rate approaching generation rate after 1000 days. This release is particle-size dependent and can be fitted with good results with a semi-empirical model which assumes diffusive movement out of the solid after the initial hold-up period.

# ISOTOPE AND RADIATION SOURCE TECHNOLOGY

## PHYSICAL ISOTOPE SEPARATION

**4618** **Plasma centrifuge for isotopic separation of krypton.** Stowell, W.R.; Sagmuller, J.R.; Gawthrop, W. E. (Battelle Columbus Labs., Columbus, OH). *Trans. Am. Nucl. Soc.*; 23: 127-128(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## RADIATION SOURCES

### USE IN MEDICAL SUPPLY STERILIZATION

*REFER ALSO TO CITATION(S) 5731*

### OTHER INDUSTRIAL USES

*REFER ALSO TO CITATION(S) 5408*

**4619** **Assessment of the potentially beneficial uses of $^{85}$Kr.** Gawthrop, W.E. (Battelle Columbus Labs., Columbus, OH); Eggers, P.E. *Trans. Am. Nucl. Soc.*; 23: 126-127(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## ISOTOPIC POWER SUPPLIES

**4620** (BNWL—1845-24) **Pacific Northwest Laboratory monthly report to the Nuclear Research and Applications Division for May 1976.** Fullam, H.T. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). Jun 1976. Contract E(45-1)-1830. 13p. Dep. NTIS $3.50.

At Hanford, strontium is separated from the high-level waste, then converted to the fluoride, and doubly encapsulated in small, highointegrity containers for subsequent long-term storage. The fluoride conversion, encapsulation and storage take place in the Waste Encapsulation and Storage Facilities (WESF). This encapsulated strontium fluoride represents an economical source of $^{90}Sr$ if the WESF capsule can be licensed for heat source applications under anticipated use conditions. The objectives of this program are to obtain the data needed to license $^{90}SrF_2$ heat sources and specifically the WESF $^{90}SrF_2$ capsules. Information is presented on: (1) long-term $SrF_2$ compatibility data; (2) chemical and physical property data on $^{90}SrF_2$; and (3) capsule property data such as external corrosion resistance, crush strength, etc.

### DESIGN AND FABRICATION

**4621 KIPS: kilowatt isotope power system.** McKenna, R.F. (Sundstrand Energy Systems, Rockford, IL); Niggeman, R.E.; Russo, F.A. *Trans. Am. Nucl. Soc.*; **23**: 122(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4622 Brayton Isotope Power System Ground Demonstrator.** Kenney, W.D. (Energy Research and Development Administration, Washington, DC); Longee, H.W.; Adland, D.L.; Hemler, R.J. *Trans. Am. Nucl. Soc.*; **23**: 122-124(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4623 Mission applications for the low-cost high performance generator (LCHPG).** Osmeyer, W.E. (Teledyne Energy Systems, Timonium, MD); Carpenter, R.T. *Trans. Am. Nucl. Soc.*; **23**: 124-125(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

### USES

**4624 Operating experience in space nuclear power.** Dix, G.P.; Kuhnapfel, R.H. (Energy Research and Development Administration, Washington, DC). *Trans. Am. Nucl. Soc.*; **23**: 122(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4625 Undersea and terrestrial applications of radioisotope thermoelectric generators (RTGs).** Rosell, F.E. Jr. (Naval Nuclear Power Unit, Ft. Belvoir, VA); Lane, S.D.; Kretschmer, T.R.; Softley, E.J.; Lowenstein, J.M.; Silliker, W.P. *Trans. Am. Nucl. Soc.*; **23**: 125-126(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

# HYDROGEN

## PRODUCTION

*REFER ALSO TO CITATION(S) 4829, 4830, 4949, 4950*

### ELECTROLYSIS

*REFER ALSO TO CITATION(S) 5245*

### THERMOCHEMICAL PROCESSES

*REFER ALSO TO CITATION(S) 4851, 4957, 4958, 4963*

**4626** (ORNL/MIT—212) **Thermodynamic properties of chromate salts in the thermochemical production of hydrogen from water.** Kodama, K.; Burch, G.M.; Cohen, A.P.; Klemm, H.A. (Oak Ridge National Lab., Tenn. (USA)). 23 Apr 1975. Contract W-7405-ENG-26. 40p. Dep. NTIS $4.00.

The reaction of potassium chromate (VI) with potassium hydroxide produces hydrogen and oxygen in a thermochemical water decomposition cycle. A reaction was selected and investigated to determine the activity of potassium chromate (V), the equilibrium constant, and to assess the cycle with these data. The results of experiments to determine the reaction equilibrium constant indicate the existence of the reaction is questionable. Side reactions which may possibly explain the phemonena observed include oxidation of the nickel reactor, water absorption of potassium hydroxide, and hydrolysis of potassium oxide. A number of recommendations resulting from experimental observations are presented.

**4627 Symposium on thermochemical generation of hydrogen held at New York, New York, April 5 to 9, 1976.** Chicago; American Chemical Society (1976). 77p. (CONF-760401—P3). $4.00.

From Conference of the division of fuel chemistry, of the American Chemical Society; New York, New York, United States of America (USA) (5 Apr 1976).

Individual abstracts were prepared for the six papers on thermochemical generation of hydrogen. (LK)

**4628 Thermochemical processes for the production of hydrogen from water.** Funk, J.E. (Univ. of Kentucky, Lexington). *Am. Chem. Soc., Div. Fuel Chem., Prepr.*; **21**: No. 3, 1-9(1976).

From Conference of the division of fuel chemistry, of the American Chemical Society; New York, New York, United States of America (USA) (5 Apr 1976).

See CONF-760401—P3.

The following aspects of thermochemical production of hydrogen are discussed: efficiency; single stage process; multistage processes; two-stage process; cycle evaluation; a hybrid cycle; and a sulfur cycle. (LK)

**4629 Reaction experiments for thermochemical water-splitting.** Gahimer, J.; Pangborn, J.; Foh, S.; Mazumder, M.; Stotz, R. (Inst. of Gas Tech., Chicago). *Am. Chem. Soc., Div. Fuel Chem., Prepr.*; **21**: No. 3, 11-26(1976).

From Conference of the division of fuel chemistry, of the American Chemical Society; New York, New York, United States of America (USA) (5 Apr 1976).

See CONF-760401—P3.

Almost all known pure thermochemical hydrogen production cycles can be grouped into five generic classes, each involving either a metal oxide or a metal halide as an intermediate. In general, those cycles with the highest-temperature endothermic reactions and the least number of reactions are the most efficient. This is expected because thermochemical cycles are special types of heat engines. The "maximum attainable" efficiency of known published cycles is about 65 percent with 1225°C input heat and assuming present technology for conversion of heat to work. The most difficult step in any thermochemical cycle is usually the one involving a change in metal oxidation state, usually the reduction. It is often necessary to operate such a step with some work input, such as electrolysis. Because of this, few of the truly efficient and workable hydrogen production cycles are purely thermochemical. Of these thermochemical hydrogen production cycles that are known to be workable with reagent-grade materials, more than two-thirds are of the group constructed from compounds of iron, chlorine, hydrogen, and oxygen. The "maximum attainable" efficiency for cycles of this group is about 47 percent with 925°C input heat and present technology for conversion of heat to work. This efficiency drops to about 43 percent if the reaction steps are assumed to operate attemperatures based on thermodynamics.

**4630 Thermochemical decomposition of water based on reactions of chromium and strontium compounds.** Bamberger, C.E.; Richardson, D.M. (Oak Ridge National Lab., TN). *Am. Chem. Soc., Div. Fuel Chem., Prepr.*; **21**: No. 3, 27-30(1976).

From Conference of the division of fuel chemistry, of the American Chemical Society; New York, New York, United States of America (USA) (5 Apr 1976).

See CONF-760401—P3.

A cycle of strontium chromates (IV), (V), and (VI) that affords lower temperatures and easier separations than prevail in a previously reported barium cycle is reported. (LK)

**4631 Promising thermochemical cycle for splitting water.** Abraham, B.M.; Schreiner, F.; Attia, A.; Jeanotte, A. (Argonne National Lab., IL). *Am. Chem. Soc., Div. Fuel Chem., Prepr.*; **21**: No. 3, 31-42(1976).

From Conference of the division of fuel chemistry, of the American Chemical Society; New York, New York, United States of America (USA) (5 Apr 1976).

See CONF-760401—P3.

A cycle based on potassium hydrogen carbonate and requiring a maximum temperature no higher than 900°K is reported. The cycle is designated ANL-4. (LF)

**4632 Thermal decomposition of some metal sulfates.** Lau, K.H.; Hildebrand, D.L.; Cubicciotti, D. (Stanford Research Inst., Menlo Park, CA). *Am. Chem. Soc., Div. Fuel Chem., Prepr.*; **21**: No. 3, 48-54(1976).

From Conference of the division of fuel chemistry, of the American Chemical Society; New York, New York, United States of America (USA) (5 Apr 1976).

See CONF-760401—P3.

Results are reported of detailed studies of the vaporization-decomposition of $MgSO_4$ and $CaSO_4$ carried out by means of the combined torsion and gravimetric Knudsen effusion method. A preliminary decomposition mechanism is discussed. (LK)

**4633 Thermochemical water splitting: the reverse Deacon reaction and alternatives.** Ulrichson, D.L.; Yeh, Y.S. (Ames Lab., IA). *Am. Chem. Soc., Div. Fuel Chem., Prepr.;* **21**: No. 3, 55-64(1976).

From Conference of the division of fuel chemistry, of the American Chemical Society; New York, New York, United States of America (USA) (5 Apr 1976).

See CONF-760401—P3.

The reverse Deacon reaction is shown to require very high temperatures (1100°K or higher) or a catalyst to obtain satisfactory reaction rates. If a high temperature is used, the reverse reaction is likely to occur as the products are cooled. The reverse reaction could be minimized by very rapid cooling but this would incur irreversible heat losses in addition to the heat required to drive the reaction. The work of separation and recycle is also very large for this reaction. Preliminary experimental work on the chlorination of magnesia and the hydrolysis of magnesium chloride indicates that both these reactions must be run as solid gas reactions. In addition, they must be run in such a way that diffusional limitations to the reaction rate are avoided. Successful demonstration of such a process may lead to a good alternate to the reverse Deacon reaction.

## STORAGE

*REFER ALSO TO CITATION(S) 5245*

### CHEMISORPTION

*REFER ALSO TO CITATION(S) 5352*

## INDUSTRIAL AND COMMERCIAL USE

**4634** (N—75-20868) **Synthetic fuels for ground transportation with special emphasis on hydrogen.** Singh, J.J. (National Aeronautics and Space Administration, Langley Station, Va. (USA). Langley Research Center). 22 Jan 1975. 50p. (NASA-TM-X—72652). NTIS $3.75.

The role of various synthetic fuels, for ground transportation in the United States, was examined for the near term (by 1985) and the longer term applications (1985-2000 and beyond 2000). Feasible options include synthetic oil, methanol, electric propulsion, and hydrogen. It is concluded that (1) the competition during the next 50 years will be for the fuels of all types, rather than among the fuels; (2) extensive domestic oil and gas exploration should be initiated concurrent with the development of several alternate fuels and related ancillaries; and (3) hydrogen, as an automotive fuel, seems to be equivalent to gasoline for optimum fuel to air mixtures. As a pollution free, high energy density fuel, hydrogen deserves consideration as the logical replacement for the hydrocarbons. Several research and development requirements, essential for the implementation of hydrogen economy for ground transportation, were identified. Extensive engineering development and testing activities should be initiated to establish hydrogen as the future automotive fuel, followed by demonstration projects and concerted efforts at public education. (Author) (GRA)

## PROPERTIES

*REFER ALSO TO CITATION(S) 5414*

# OTHER SYNTHETIC AND NATURAL FUELS

*REFER ALSO TO CITATION(S) 4398*

## HYDROCARBON FUELS

*REFER ALSO TO CITATION(S) 4414, 5482*

**4635** (PB—242774) **Process and environmental technology for producing SNG and liquid fuels. Environmental protection technology series.** Beychok, M.R. Mar 1975. Contract EPA-68-03-2136. 152p. NTIS $6.25.

This report presents the process technology and environmental factors involved in the emerging industries for providing new supplemental energy supplies from non-conventional sources. It includes: (1) the production of substitute natural gas (SNG) from coal, crude oil and naphtha, (2) importing overseas gas supplies in the form of liquefied natural gas (LNG) and as liquid methanol, (3) the regasification of LNG, (4) the production of liquid fuels from oil shale, and (5) the liquefaction of coal to produce clean fuels. The report also includes introductory chapters to familiarize the reader with the technology of oil and gas processing, heat balances, fuel combustion and stack gases, thermal efficiencies, and water balances. (GRA)

**4636 Two-stage methane production from solid wastes.** Keenan, J.D. New York; American Society of Mechanical Engineers (1974). 13p. $3.00.

From Winter annual meeting of the American Society of Mechanical Engineers; New York, NY, USA (17 Nov 1974).

The National Center for Energy Management and Power, University of Pennsylvania, discusses the development of methods for the economic production of methane gas by anaerobic digestive of organic matter—a process widely used for the stabilization of sewage solids. Research reported was directed toward the potential of 2-stage digestion for generating fuel gas from particulate organic fuel materials. A 2-stage thermophilic digestive system was established on a particulate-simulated organic solid waste substrate by means of pH control of the 1st stage. The 1st-stage gaseous end-products consist of a gaseous phase containing approximately 98 percent carbon dioxide, 2 percent hydrogen, and some hydrogen sulfide. The aqueous 1st-stage effluent contains 13 or 14 g total volatile acids as acetic acid/liter. The product gas from the 2nd-stage digester is enriched for methane, bringing its methane content to 80 percent. The heat of combustion of the off-gases is 800 Btu/SCF by the use of 2-stage digestion. The 2-stage-digester operating technique provided greater stability than did the conventional single-stage control digesters. Changes occurring in the digester environment following batch feeding include variations in pH, volatile acids, gas composition, and rates of gas production. Changes in pH and volatile acids concentration present intermittent stresses, with potentially adverse effects on digester stability. No significant differences were observed with single-stage digesters operating in the mesophilic (99°F or 37°C) or the thermophilic (118°F or 48°C) ranges. The 1st stage can be operated at room temperature without loss of energy conversion efficiency, that is, at no significant reduction in 2nd-stage methane productivity.

**4637 Liquid phase methanation of high concentration CO synthesis gas.** Blum, D.B.; Sherwin, M.B.; Frank, M.E. *Am. Chem. Soc., Div. Fuel Chem., Prepr.;* **19**: No. 3, 44-56(1974).

Chem Systems Inc. believes that the Liquid Phase Methanation process can become an economic, reliable, and versatile method of converting synthesis gas mixtures to high-Btu gas. The process consists essentially of pumping an inert liquid upward through a reactor at a velocity sufficient to fluidize the catalyst and remove the reaction heat. A low-Btu gas is passed concurrently up the reactor where it is catalytically converted to a methane-rich gas stream. The exothermic reaction heat is absorbed mainly by the liquid as sensible heat and partly by vaporization. The overhead product gases are condensed to remove the product water and recover any vaporized liquid for recycle. The main liquid flow is circulated through a heat exchanger where the heat of reaction is recovered by generating high-pressure steam. To date, development of the process (under OCR-A.G.A. sponsorship for SNG production from coal) has completed the exploratory research and development stage and completed 90 percent of the construction and operation of a full-scale integrated pilot unit (PDU) and 40 percent of that of a full-scale integrated pilot plant. The pilot plant will incorporate a 2 x 15 ft reactor of the same basic design as the one used for the PDU and bench-scale unit. The unit will be skid-mounted so that it can be moved to different plant locations for testing with synthesis gas from different coal gasification processes. At this time, the 2 most logical locations include IGT's HYGAS plant in Chicago and the $CO_2$ Acceptor plant in Rapid City, S.D.

**4638 Synthesis of methane in hot gas recycle reaction: pilot plant tests.** Haynes, W.P.; Forney, A.J.; Elliott, J.J.; Pennline, H.W. *Am. Chem. Soc., Div. Fuel Chem., Prepr.;* **19**: No. 3, 10-42(1974).

The U.S. Bureau of Mines demonstrated in a series of experiments that the hot gas recycle methanation system is a usable and operable system. Temperature control was excellent with a total gas recycle ratio of 10:1 and CO concentrations as high as 4.3 percent in the mixed feed entering the catalyst bed. The investigation was conducted as part of a program to extend the life of the catalyst in a hot gas recycle reactor system by determining the effects of some of the process variables (effects of cold gas recycle, approach to equilibrium, and catalyst deactivation) and comparing the performance of a bed of pelleted nickel catalyst with a bed of parallel plates coated with Raney nickel. The sprayed plates were shown to promote a higher methane yield/lb of catalyst, last longer, lower CO concentration in the product gas, and reduce the pressure drop across the catalyst bed. A decrease in the cold recycle ratio increased the concentration of water vapor, hydrogen, and carbon dioxide, and decreased the methane concentration in the product gas. In the catalyst-deactivation tests, the sulfur content of the feed gas was held to less than 0.1 ppM to limit sulfur poisoning. The catalyst was found to be deactivated by iron deposits. Analyses of the spent methanation catalysts showed that the Raney nickel with the higher iron concentration generally led to greater carbon deposits. Other poisons were identified as nickel carbide and oil entrainment from the hot gas recycle compressor.

**4639 Equilibrium considerations in the methane synthesis system.** Gruber, G. *Am. Chem. Soc., Div. Fuel Chem., Prepr.;* **19**: No. 3, 117-138(1974).

FMC Corp. investigated the equilibria of the methanation reaction, shift reaction, and carbon-deposition reaction, and developed a series of carbon-laydown curves plotted on a unique coordinate system which corresponds to common starting composition variables and can be used to rapidly determine the effect of possible starting gas composition, pressure, and temperature on the product-gas quality and useful operating regions. All possible starting compositions are considered over a temperature range of 625 to 3140°F and pressure range of 30 to 300 atm. The curves are not limited to a single-stage reaction but can be used for multiple-stage reactors with arbitrary amounts of diluents and recycle gas.

**4640 Development of methanation catalyst for SNG processes.** Hausberger, A.L.; Atwood, K.; Knight, C.B. *Am. Chem. Soc., Div. Fuel Chem., Prepr.;* **19**: No. 3, 70-104(1974).

Catalysts and Chemicals Inc. demonstrated that the methanation activity of a catalyst increases with increased nickel content and decreases with increased particle size and that an increase in the steam/gas ratio of the feed gas tends to increase carbon monoxide conversion but does not affect the methanation rate. These findings are based on a laboratory investigation of over 40 catalysts to determine the optimum catalyst for the methanation of synthesis gas from coal and to develop an applicable kinetic system. The investigation involved determination of the necessary catalyst loading design operating conditions, effect of particle size, effect of various trace constituents ($H_2S$, HCl, NO/sub x/, methanol, ethane, ethylene, propane, propylene, and benzene) on catalyst performance, and resistance of the catalyst to various steam/gas ratios. The report includes a complete bibliography of the literature search on reported developments and kinetics which were used to develop the kinetic system.

**4641 Velocity of sound in dense fluid methane.** Straty, G.C. *Cryogenics;* **14**: 367-370(Jul 1974).

The Cryogenics Division of the National Bureau of Standards measured the velocity of sound in saturated and compressed fluid methane (99.97 percent pure) from 91°K to 186°K and from 100°K to 300°K, respectively, at pressures of 35 NM/cu m. The measurements were made to fulfill the need for accurate thermodynamic and transport properties data on LNG with its increased engineering and development applications in handling, storage, and transportation. (Sound velocity measurements, when combined with newly available pressure, density, and temperature (P rho T) data, provide a convenient and accurate method of obtaining certain thermodynamic quantities which cannot be easily determined by any other means, as well as providing a sensitive check on the P rho T surface and its derivatives.) The measured sound velocities of the saturated liquid are tabulated along with the density, the calculated compressibility, and the specific heat ratio, and shown to be generally higher than the sound velocities interpolated from data from Yu. P. Blagoi et al. and A. Van Dael et al., and the sound velocities calculated by R. D. Goodwin directly from P rho T and specific heat data. The sound velocities for the compressed and saturated fluid are also plotted against density along several isotherms ranging from 100° to 300°K. The uncertainty of the derived isentropic compressibilities is estimated at +-0.2 percent from the combined uncertainties of the experimental densities (+-0.1 percent) and the equation-of-state correlation. The uncertainty of the specific heat ratio is indicated as less than 0.1 percent at the higher temperatures, increasing somewhat for the low-temperature high-density liquid where the derivative used to obtained the specific heat ratio is very large or difficult to obtain accurately.

**4642 Method for simultaneously producing synthetic natural gas and high octane reformate.** Wilhelm, F.C. (to Universal Oil Products Co.). US Patent 3,825,487. 23 Jul 1974. vp.

Universal Oil Products Co. modified the conventional catalytic reforming process by using a special catalyst which possesses a high selectivity for methane, a low selectivity for $C_2$ to $C_4$ hydrocarbons, and a high selectivity for $C_5$ + hydrocarbons. SNG and a high-octane reformate stream are produced by contacting a hydrocarbon feedstock boiling in the gasoline range and hydrogen, at SNG production conditions, with a catalytic composite comprising a porous carrier material containing, on an elemental basis, about 0.01 to 2 wt percent of a platinum group metal, about 1 to 5 wt percent nickel, and about 0.01 to about 5 wt percent of a Group IVA metal. SNG production conditions generally utilized include temperatures of 900° to 1200°F, pressures of 0 to 350 psig, liquid hourly spaced velocity of 0.5 to 3 $hr^{-1}$ and a mole ratio of hydrogen to hydrocarbon of 1:1 to 5:1.

**4643 Production of methane and aromatics.** Heinemann, H.; Weisz, P.B. (to Mobil Oil Corp.). US Patent 3,827,867. 6 Aug 1974. vp.

Mobil Oil Corp.'s process for SNG production uses a combined aromatization and light gas hydrogenolysis approach. Naphtha or light gas hydrocarbons are initially aromatized in contact with a ZSM-5 type of synthetic aluminosilicate zeolite molecular sieve at a space velocity of 0.1 to 15 WHSV, a temperature of 650°-1500°F, and a pressure of 1-30 atm absolute. About 30 wt percent of the resulting gas is a mixture of aromatic hydrocarbons, the remainder a gaseous mixture of hydrogen and lower-molecular-weight hydrocarbons (atom ratio of about 1 carbon atom to 4 hydrogen atoms). This gas is contacted with a hydrogenolysis catalyst, such as nickel, at about 525°-1000°F and about 0-200 psig to convert most or all of the hydrogen and the carbon in the hydrocarbon components to a synthetic natural gas which is thermally and physically compatible with natural gas.

**4644 Fluidized bed hydrogenation.** Thompson, B.H. (to British Gas Corp.). US Patent 3,830,637. 20 Aug 1974. vp.

In a modification of British Gas Corp.'s FBH process for hydrogenation of hydrocarbon oils to a fuel gas, heat is supplied to the reactants in a fluidized-bed hydrogenator by combustion of carbonaceous materials formed in the hydrogenator. A combustion chamber is included, either as an integral part of the reactor or as a separate unit, in order to avoid oxidizing some of the feedstock and/or desirable products of the process, by controlled admission of air or oxygen into the reactor for additional heat.

**4645 Process and system for the production of substitute pipeline gas.** Krawitz, L.; Maslyk, F.J.; Patterson, L.W. US Patent 3,836,344. 17 Sep 1974. vp.

Substitute pipeline gas may be produced from crude oil by first distilling the crude oil into 3 fractions. The light fraction (bp below 375°F) after removal of sulfur is catalytically gasified with steam and treated for removal of $CO_2$ and steam to produce a gas of 700-800 Btu/SCF. The middle fraction (bp of 375°-650°F) is thermally cracked in the presence of dilution steam in a pyrolysis furnace. A steam of $C_3$ and lighter hydrocarbons (1300-1400 Btu/SCF) produced from this pyrolysis is blended with the gas produced from the light fraction to yield a fuel gas product of 950-1000 Btu/SCF. This product gas can be blended (40:60 or 50:50) with high-Btu natural gas to produce synthetic pipeline gas. By-products include low-sulfur residual fuel oil and aromatic hydrocarbons.

**4646 Two stage process for the conversion of heavy hydrocarbons to a methane rich gas stream.** Aldridge, C.L. (to Esso Research and Engineering Co.). US Patent 3,838,993. 1 Oct 1974. vp.

Esso's new 2-stage oil gasification process is superior to a 1-stage process because of greater methane yield and higher thermal efficiency due to the heat exchange between the 2 stages. In the process, a hydrocarbon feedstock containing at least 10 wt percent hydrocarbons boiling above 600°F (such as crude, residuum, asphalt, or shale oil, to which coke or coal may be added) is contacted with steam in a 1st reaction zone containing a particulate catalyst bed of non-molten alkali metal (at least 1 wt percent of the total solids of bed) to produce a vaporous product consisting of $H_2$, CO, $CO_2$, and $CH_4$ and solid carbonaceous material. A portion of the catalyst and the vaporous product are passed to a 2nd reaction zone for further conversion to methane. Each of the stages is operated at pressures above 200 psig and temperatures between 1000° and 1500°F.

**4647** **History of SNG at Boston Gas: reasons, experiences, opinions.** Buckley, C.P. (Boston Gas Co.). *Am. Gas Assoc., Oper. Sect., Proc.;* T167-T169(1975).

Certain aspects of construction, startup, operator training and operating experience are discussed.

**4648** **Brief review of brooklyn Union's SNG plant operation.** Hippeli, R.F. (Brooklyn Union Gas Co.). *Am. Gas Assoc., Oper. Sect., Proc.;* T170-T173(1975).

Process, plant areas, storage, and various devices are discussed and presented diagrammatically. 1 ref.

**4649** **Startup and initial operating experience of Public Service Electric and Gas Company Linden SNG plant.** Stubblebine, G.W. *Am. Gas Assoc., Oper. Sect., Proc.;* T174-T178(1975).

Overall survey is presented.

**4650** **Startup of Gasco's SNG plant.** Walker, B.D. (Gasco, Inc). *Am. Gas Assoc., Oper. Sect., Proc.;* T179-T181(1975).

Team roles and problem solving are discussed.

**4651** **Northern Illinois Gas Company supplemental natural gas plant startup.** Merriam, N.W.; White, R.J. *Am. Gas Assoc., Oper. Sect., Proc.;* T182-T184(1975).

Staffing and training and initial problems are described.

**4652** **Start-up and operating experience of an sng plant: Commonwealth Natural Gas.** Wimer, D.C. *Am. Gas Assoc., Oper. Sect., Proc.;* T185-T186(1975).

Systematic review and future requirement diagram are presented.

## ALCOHOL FUELS

*REFER ALSO TO CITATION(S) 4634, 4635, 5302*

## INORGANIC HYDROGEN COMPOUND FUELS

*REFER ALSO TO CITATION(S) 4401, 5237*

## SOLID WASTE FUELS

*REFER ALSO TO CITATION(S) 4436, 4440*

## LIQUID WASTE FUELS

*REFER ALSO TO CITATION(S) 4436*

# HYDRO ENERGY

**4653** **Role of natural gas in energy conservation.** Barbeau, G. *Ingenieur (Montreal);* **61**: No. 310, 23-25(Nov-Dec 1975). (In French).

It is noted that the Canadian gas industry already foresees certain difficulties in satisfying both Canadian internal demand for natural gas and export demand. In view of this, the Canadian government has proposed a four-phase program of energy conservation which includes a restructuring of rates designed to reduce energy consumption by imposing higher rates on large consumers. The author recommends that the new rate structure be applied gradually to minimize certain problems that could arise during the transition period.

# SOLAR ENERGY

**4654** **Applied solar energy. An introduction.** Meinel, A.B.; Meinel, M.P. Reading, MA; Addison-Wesley Publishing Co. (1976). 666p.

This book is an introduction into the theory that must be mastered in order to engineer and evaluate the performance of solar energy systems. An important goal in solar energy applications is the ability to calculate output from a proposed design application and thereby establish the value of the energy delivered and a fair price for the system. To this end the authors build the necessary background and information in successive chapters, culminating in a section on representative applications. (WDM)

## RESOURCES AND AVAILABILITY

*REFER ALSO TO CITATION(S) 5823*

## SOLAR ENERGY CONVERSION

*REFER ALSO TO CITATION(S) 5441*

**4655** (CONF-760131—, pp 563-586) **Organic solar cell exploratory research.** Valenty, S.J. (General Electric Co., Schenectady, NY). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

This experimental program is formulated to obtain an understanding of the principles governing the photovoltaic effect in organic materials on the molecular level, and to apply these principles to the design and fabrication of laboratory devices having a photovoltaic organic polymer film as their key element (WDM)

### PHOTOVOLTAIC CONVERSION

**4656** (CONF-760131—, pp 431-455) **Ternary compound thin film solar cells.** Kazmerski, L.L. (Univ. of Maine, Orono). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

The purpose of this project is the investigation of I—III—$VI_2$ semiconductor compound thin films and the application of these materials in photovoltaic devices. Because of certain suitable properties, the initial focus of this study has been on three materials: $CuInS_2$, $CuInSe_2$, and $CuInTe_2$. Long-range development for ternary devices is emphasized in this program. The specific objectives of this research includes: (1) The identification and production of device quality thin films of $CuInS_2$ on suitable substrates; (2) The demonstration of homojunction viability for $CuInS_2$ thin film solar cells; (3) The growth and characterization of $CuInSe_2$ and $CuInTe_2$ films for photovoltaic applications; and, (4) Possible thin film heterojunction demonstration involving these ternary compounds. Of special interest in this category is the p-$CuInSe_2$/n-CdS thin film solar cell. (WDM)

**4657** (CONF-760131—, pp 459-473) **Feasibility investigation of growing gallium arsenide single crystals in ribbon form.** Berkowitz, J.B. (Arthur D. Little, Inc., Cambridge, MA). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

A program was initiated to determine the feasibility of producing GaAs single crystal ribbons suitable for solar cell substrates. Constrained, encapsulated molten zones are passed through rectangular polycrystalline feed material to form single crystal ribbons. The objective of this program is to grow 10 cm x 1 cm x 0.1 cm single crystals by a process that is amenable to continuous growth. (WDM)

**4658** (CONF-760131—, pp 475-492) **Low cost AMOS solar cell development.** Stirn, R.J. (Jet Propulsion Lab., Pasadena, CA). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

A program to investigate the feasibility of growing relatively large grain polycrystalline GaAs on recrystallized Ge films and the characteristics of AMOS solar cells fabricated on such films and on other poly films of GaAs was begun in late January, 1976. Concepts of the device structure and possible large scale processing line, a breakdown of material costs, and a brief description of the planned approaches are discussed. (WDM)

**4659** (CONF-760131—, pp 493-501) **Heteroepitaxial deposition of gallium arsenide by liquid phase growth.** Stevenson, D.A.; Elliot, A.G.; Mattes, B.L. (Stanford Univ., CA). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

The objective of this program is the study of heteroepitaxial deposition of gallium arsenide (GaAs) by liquid phase growth, with specific reference to the synthesis of thin films of GaAs for solar cell applications. (WDM)

**4660** (CONF-760131—, pp 503-513) **Solar energy research activities at the IBM Thomas J. Watson Research Center.** Woodall, J.M. (IBM Watson Research Center, Yorktown Heights, NY). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

A Ga/sub 1-x/Al/sub x/As—GaAs cell designed to operate at 18 percent AMO efficiency and 6 percent efficiency at 300°C was fabricated, measured, and analyzed. A solar tracking system employing high efficiency Ga/sub 1-x/Al/sub x/As—GaAs cells used with Fresnel lens at concentrations of greater than 500x was designed and built. A GaAs CVD system was developed to provide material for thin film cell studies. Performance of Schottky barrier type GaAs cells and performance modeling of polycrystalline cells was studied. Optical and thermal properties of dendritic tungsten photothermal device were characterized. (WDM)

**4661** (CONF-760131—, pp 517-538) **Silicon Schottky photovoltaic diodes for solar energy conversion.** Anderson, W. (Rutgers-The State Univ., New Brunswick, NJ). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

The overall objective is to produce a 12 percent efficient Schottky solar cell using economical silicon and fabrication methods. This is to be accomplished through optimization of current by use of new AR coatings, voltage by interface studies, and fill factor by deposition studies. Further studies include environmental effects, thin epitaxial silicon films, surface effects, and new sources of silicon.

**4662** (CONF-760131—, pp 539-559) **Solid phase epitaxy and backscattering.** Liau, Z.L.; Lau, S.S.; Nicolet, M.A.; Mayer, J.W. (California Inst. of Tech., Pasadena). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

The overall objectives of the investigation are (1) to study the low temperature solid-phase epitaxy of Si layers obtained by interdiffusion processes. (2) To investigate the use of backscattering spectrometry for the determination of composition in thin film structures used in low cost solar cells. (WDM)

**4663** (CONF-760131—, pp 587-615) **Photochemical conversion of solar energy.** Lichtin, N.N. (Boston Univ.). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

Objectives of the project are (1) construction of a photogalvanic cell with 5 percent engineering efficiency for conversion of incident solar energy to electricity, appropriate for use as an area device, and (2) longer range goal: a practicable light-recharged storage battery. (WDM)

**4664** (CONF-760131—, pp 617-628) **Semiconductor-electrolyte photovoltaic energy converter.** Anderson, L.B.; Swartz, J.M. 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

The evaluation of the feasibility and practicality of a solar cell consisting of a semiconductor surface in contact with an electrolyte solution is proposed. Preliminary experimental and theoretical work has indicated that high quantum efficiencies and high theoretical conversion efficiencies are obtained with this cell configuration, while also identifying several areas which merit further study. (WDM)

**4665** (CONF-760131—, pp 629-646) **Photo-decomposition of water at semiconductor electrolyte interface.** Ghosh, A.K.; Maruska, H.P. (Exxon Research and Engineering Co., Linden, NJ). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

The object of the program is to sensitize $TiO_2$ to sunlight by impurity doping, dye sensitization, or heterojunction formation. The initial goal is to reach an efficiency of 5 percent. (WDM)

**4666** (CONF-760131—, pp 647-656) **Cuprous oxide photovoltaic cells.** Trivich, D.; Wang, E.Y.; Komp, R.J. (Wayne State Univ., Detroit, MI). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

The objective is to prepare low cost cuprous oxide photovoltaic cells of good efficiency. It is expected that these will be front wall cells using single crystal cuprous oxide, prepared by oxidation and annealing, with Schottky barrier junctions. (WDM)

**4667** (CONF-760131—, pp 657-682) **Investigation of low cost solar cells based on $Cu_2O$.** Olsen, L.C. (Joint Center for Graduate Study, Richland, WA). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

An experimental system for controlled oxidation of copper was established. It appears that the $N_2$-cooled process may be useful for thin-film growth. A collection efficiency measurement capability was also established. Several computer codes were developed for device analysis. In particular, an approach to MIS solar cell calculations was developed and an appropriate computer program written. Initial estimates of potential $Cu/Cu_2O$ solar cell performance were made. (WDM)

**4668** (CONF-760131—, pp 683-698) **Cadmium stannate selective optical films for solar energy applications.** Haacke, G. (American Cyanamid Co., Stamford, CT). 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

The objective of this program is the development of low sheet resistance (1 ohm/square), transparent cadmium stannate electrodes and their incorporation and testing in backwall CdS and silicon solar cells. The program also includes the development of an economical spray deposition method. (WDM)

**4669** (CONF-760131—, pp 429) **Progress in InP/CdS single crystal solar cells.** Bachmann, K.J. (Bell Labs., Murray Hill, NJ); Buehler, E.; Shay, J.L.; Wagner, S. 1976.

From Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review; Lake Buena Vista, Florida, United States of America (USA) (20 Jan 1976).

In Proceedings of the second ERDA semiannual Solar Photovoltaic Conversion Program review.

**4670** **Irradiation effects on high efficiency Si solar cells.** Nguyen Duy, T.; Amingual, D.; Colardelle, P. (Societe Anonyme de Telecommunications, 75 - Paris (France)); Bernard, J. (Office National d'Etudes et de Recherches Aerospatiales (ONERA), 31 - Toulouse (France). Centre d'Etudes et de Recherches). pp 651-657 of In Evaluation de l'action de l'environnement spatial sur les materiaux. Toulouse; Centre National d'Etudes Spatiales (Jun 1974). (In French)

From International conference on evaluation of space environment on materials; Toulouse, France (17 Jun 1974).

By optimizing the diffusion parameters, high efficiency cells are obtained with 2ohmsxcm (13.5% AMO) and 10ohmsxcm (12.5% AMO) silicon material. These new cells have been submitted to radiation tests under 1MeV, 2MeV electrons and 2.5MeV protons. Their behavior under irradiation is found to be dependent only on the bulk material. By using the same resistivity silicon, the rate of degradation is exactly the same as those of conventional cells. The power increase, due to a better superficial response of the cell, is maintained after irradiation. These results show that new high efficiency cells offer an E.O.L. power higher than conventional cells.

### THERMIONIC CONVERSION

**4671** (N—75-20878) **Reflector-absorber systems for solar thermionic converters.** Kelm, S. (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt e.V., Koeln (Germany, F.R.)). Jan 1975. Translation of DLR-FB—74-23. (ESRO-TT—123). 59p. NTIS $4.25.

Some reflector-absorber systems are described for attaining temperatures from 1000 to 1300 C by using solar energy. Thermionic converters can operate in this temperature range suitable for the production of electric energy. The absorber is designed in such a way that the absorber is accommodated to the converter as regards the operating temperature and heat transfer. Some applications of solar thermionic energy systems for space and earth are discussed. For large-scale solar energy conversion a conventional steam power station can be added to the thermionic system for producing more electric power.

## SOLAR THERMAL POWER PLANTS

### ORBITAL POWER PLANTS

*REFER ALSO TO CITATION(S) 5262*

### TOWER FOCUS POWER PLANTS

**4672** **Theory of concentrators of solar energy on a central receiver for electric power generation.** Riaz, M.R. (Univ. of Minnesota, Minneapolis). *J. Eng. Power;* **98**: No. 3, 375-383(Jul 1976).

From ASME Winter annual meeting; Houston, TX, USA (30 Nov 1975).

The modeling of the performance of large-area solar concentrators for central receiver power plants is formulated using a continuum field representation of ideal heliostat arrays that accounts for two governing factors: the law of reflection of light rays imposes steering constraints on mirror orientations; the proximity of mirrors creates shadow effects by blocking the incident and/or reflected solar radiation. The results of a steering analysis which develops the space-time characteristics of heliostats and of a shadow analysis which determines the local effectiveness of mirrors in reflecting solar energy to a central point are combined to obtain in closed analytical form the global characteristics of circular concentrators. These characteristics which appear as time profiles for mirror orientations, for effective concentration areas (i.e., reflected solar flux), and for concentration ratios, establish theoretical limits of performance against which actual or realistic solar power systems can be compared and assessed.

## OCEAN THERMAL GRADIENT POWER PLANTS

*REFER ALSO TO CITATION(S) 5237*

**4673** (NSF/RANN/SE/GI—34979/TR/75/1) **Mechanics and structural design of large diameter immersed reinforced concrete cylindrical shells.** Dzialo, F.J.; Heravi, P. (Massachusetts Univ., Amherst (USA)). Jan 1975. 24p. National Science Foundation, Washington, DC.

A limit design approach for the preliminary design of large diameter immersed reinforced concrete cylindrical shells has been developed. The method is applied to the design of the University of Massachusetts Mark II Ocean Thermal Gradient Machine. Equations for moments, axial forces, and shears for design are summarized for various components of the outer shell of the cylindrical hull of the machine. Assuming a given thickness, computer results are presented, and typical cross-sections with necessary steel reinforcing for moment and axial forces are given.

## SOLAR RADIATION UTILIZATION

### SPACE HEATING AND AIR CONDITIONING

*REFER ALSO TO CITATION(S) 5236*

**4674** (COO/2688—76/8) **InterTechnology Corporation proposed systems level plan for solar heating and cooling commercial buildings. National Solar Demonstration Program. Executive summary.** (InterTechnology Corp., Warrenton, Va. (USA)). May 1976. Contract E(11-1)-2688. 38p. (ITC—240576). Dep. NTIS $4.00.

The goals of the National Solar Heating and Cooling Demonstration Program for non-residential buildings are embodied in the following: (1) Demonstrate the ultimate economic and technical feasibility of solar heating and combined heating and cooling. (2) Stimulate industry to produce and market solar equipment. (3) Stimulate a commercial market for solar systems. The systems level plan is designed to address the above stated goals as they relate to the building community associated with the commercial sector of the economy. (WDM)

## SOLAR COLLECTORS AND CONCENTRATORS

**4675** (Y/DA—6701(Rev.1)) **Selective absorptivity of carbon coatings.** Schreyer, J.M.; Schmitt, C.R.; Googin, J.M.; Whitehead, H.D. (Oak Ridge Y-12 Plant, Tenn. (USA)). Jul 1976. Contract W-7405-ENG-26. 18p. Dep. NTIS $3.50.

Preliminary solar absorption tests have been made on copper plates with various carbon coatings, and comparisons were made with known high-solar-absorbing coatings. It was demonstrated that certain carbon coatings exhibited higher absorptivity at shorter wavelengths and lower emissivity at longer wavelengths than known commercial coatings. Comparison tests have been conducted on two commercial solar collectors, one coated with a commercial black velvet paint and the other with one of the promising carbon coatings. Evaluation of the data indicates comparable or slightly higher results for the carbon-coated collector, with the potential of a significant cost savings.

# GEOTHERMAL ENERGY

## RESOURCE STATUS AND ASSESSMENT

*REFER ALSO TO CITATION(S) 5183*

### USA

**4676** **Geothermal energy: economic potential of three sites in Alaska.** Rosenbruch, J.C.; Bottge, R.G. (Bureau of Mines, Washington, D.C. (USA)). 1975. vp. Bureau of Mines, Washington, DC.

The Bureau of Mines evaluated the prospects for using geothermal energy to generate electricity for mines in remote areas. Given the development of a geothermal resource for this purpose, the subsidiary uses of space heating and agriculture were then examined to see if other industries might be viable given a cheap source of heat energy. Sites investigated were located in three areas of Alaska: Kobuk in the northwest, Unalaska in the southwest, and Stikine River in the southeast. Each site was relatively close to mineral deposits whose prospects for development would be enhanced with cheap power. 30 refs.

## GEOLOGY, HYDROLOGY, AND GEOTHERMAL SYSTEMS

**4677** **Numerical modeling of geothermal systems (abstract).** Sorey, M.L. (Geological Survey, Menlo Park, CA). *Geol. Soc. Am., Abstr. Programs;* **6**: No. 7, 962(Oct 1974).

From 1974 annual meetings of the Geological Society of America; Miami Beach, FL, USA (18 Nov 1974).

**4678** **Discrimination of hydrothermally altered and unaltered rocks in visible and near-infrared multispectral images.** Rowan, L.C.; Goetz, A.F.H.; Ashley, R.P.; Siegal, B.S. (Geological Survey, Reston, VA). *Geophysics;* **41**: No. 2, 371-372(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

### USA

*REFER ALSO TO CITATION(S) 4716*

**4679** (LA—6433-MS) **Morphology of zircons from Precambrian rocks penetrated by geothermal test hole GT-2.** Heimlich, R.A. (Los Alamos Scientific Lab., N.Mex. (USA)). Jul 1976. Contract W-7405-eng-36. 10p. Dep. NTIS $3.50.

Analysis of zircons separated from nine samples of Precambrian rocks in the interval 786 to 2902 m, along geothermal test hole GTz2, reveals the presence of large percentages of light-colored as well as some dark brown grains in each sample. A majority of the zircons in all samples are rounded or subrounded, and a large number in all but two samples exhibit overgrowths. Some zircons from all samples possess extinction angles, many exhibit zoning, and a small percentage show truncated zoning. Zircon mean lengths and mean widths fall within narrow ranges. Mean elongations cluster near 2.0, typically, and elongation histograms are primarily bimodal. Reduced major axes vary in position, length, and slope. Collectively, the mean elongations, rounding index, euhedrism, overgrowths, extinction angles, truncated zoning, and reduced major axis data suggest that these zircons are detrital in nature. Thus the rocks in which they occur are inferred to be paragneisses.

**4680** (USGS-OFR—74-271) **Geothermal systems of northern Nevada.** Hose, R.K.; Taylor, B.E. (Geological Survey, Reston, Va. (USA)). 1974. 30p. TIC.

Hot springs are numerous and nearly uniformly distributed in northern Nevada. Most occur on the flanks of basins, along Basin and Range (late Miocene to Holocene) faults, while some occur in the inner parts of the basins. Surface temperatures of the springs range from slightly above ambient to boiling; some springs are superheated. Maximum subsurface water temperatures calculated on the basis of quartz solubility range as high as 252°C, although most are below 190°C. Flows range from a trickle to several hundred liters per minute. The Nevada geothermal systems differ markedly from the power-producing system at The Geysers, Calif., and from those areas with a high potential for power production (e.g., Yellowstone Park, Wyo.; Jemez Mountains, N. Mex.). These other systems are associated with Quaternary felsic volcanic rocks and probably derive their heat from cooling magma rather high in the crust. In northern Nevada, however, felsic volcanic rocks are virtually all older than 10 million years, and analogous magmatic heat sources are, therefore, probably lacking. Nevada is part of an area of much higher average heat flow than the rest of the United States. In north-central Nevada, geothermal gradients are as great as 64°C per kilometer in bedrock and even higher in basin fill. The high gradients probably result from a combination of thin crust and high temperature upper mantle. It is suggested that the geothermal systems of northern Nevada result from circulation of meteoric waters along Basin and Range faults and that their temperature chiefly depends upon (1) depth of circulation and (2) the geothermal gradient near the faults.

**4681** **Hydrologic reconnaissance of geothermal areas in Black Rock Desert and Carson Desert, Nevada (abstract).** Olmsted, F.H. (Geological Survey, Menlo Park, CA). *Geol. Soc. Am., Abstr. Programs;* **6**: No. 3, 232(Feb 1974).

From 70. annual meeting of the Cordilleran section of the Geological Society of America; Las Vegas, NV, USA (29 Mar 1974).

**4682** **Geothermal waters in the Jemez Mountains volcanic region, north-central New Mexico (abstract).** Trainer, F.W. (Geological Survey, Albuquerque, NM). *Geol. Soc. Am., Abstr. Programs;* **6**: No. 7, 991(Oct 1974).

From 1974 annual meetings of the Geological Society of America; Miami Beach, FL, USA (18 Nov 1974).

**4683** **Geologic controls over hot water migration at selected hot springs, Southwestern Montana (Abstract).** Chadwick, R.A.; Galloway, M.J.; Goering, J.D. (Montana State Univ., Bozeman). *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1393(Aug 1976).

From 25. annual meeting of AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

**4684** **Alvord Valley, Oregon geothermal invesigation (Abstract).** Cleary, J.G. (Univ. of Montana, Missoula). *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1394(Aug 1976).

From 25. annual meeting of AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

**4685** **Proposed geothermal circulation pattern, Corwin Springs—Gardiner Area, Montana (Abstract).** Struhsacker, E.M. (Montana State Univ., Bozeman). *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1411-1412(Aug 1976).

From 25. annual meeting of AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

**4686** **Corwin Springs known geothermal resources area, Park County, Montana (Abstract).** Taylor, H.C.J. (Geological Survey, Billings, MT). *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1412(Aug 1976).

From 25. annual meeting of AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

## GEOTHERMAL EXPLORATION AND EXPLORATION TECHNOLOGY

### GEOPHYSICAL TECHNIQUES AND SURVEYS

*REFER ALSO TO CITATION(S) 4684, 5774*

**4687** (USGS-OFR—74-249) **Geothermal investigations in Idaho. Part 3. An evaluation of thermal water in the Weiser area, Idaho.** Young, H.W.; Whitehead, R.L. (Geological Survey, Reston, Va. (USA)). 1974. 85p. TIC.

The Weiser area encompasses about 200 square miles in southwest Idaho and contains two thermal water areas: (1) the Crane Creek subarea, which is 12 miles east of Weiser, Idaho, and (2) the Weiser Hot Springs subarea, which is 5 miles northwest of Weiser. Volcanic and sedimentary rocks of Miocene to Pleistocene age have been faulted and folded to form the northwest-trending anticlines present in much of the area. Basalt of the Columbia River Group or underlying rocks are believed to constitute the reservoir for the hot water. Gravity and magnetic anomalies are present in both subareas. A preliminary audio-magnetotelluric survey indicates that a shallow conductive zone is associated with each thermal site. Above-normal ground temperatures measured at a depth of 1 metre below the land surface in the Weiser Hot Springs subarea correlate with relatively high concentrations of boron in underlying ground waters, which, in turn, are usually associated with thermal waters in the study area. Sampled thermal waters are of a sodium chloride sulfate or sodium sulfate type, having dissolved-solids concentrations that range from 225 to 1,140 milligrams per litre. Temperatures of sampled waters ranged from 13° to 92.0°C. Minimum aquifer temperatures calculated from chemical analysis of water, using geochemical thermometers, were 170° and 150°C in the Crane Creek and Weiser Hot Springs subareas, respectively. Estimated maximum temperatures ranged from 212° to 270°C and 200° to 242°C, respectively, in these subareas. The probable heat sources for both subareas are (1) young magmatic intrusive rocks underlying the basalt or (2) above-normal temperatures resulting from thinning of the earth's crust. Maps are included.

**4688** (USGS-OFR—75-668) **Principal facts for gravity stations in Gerlach and San Emidio Known Geothermal Resource Areas (KGRA), Nevada.** Peterson, D.L.; Dansereau, D.A. (Geological Survey, Reston, Va. (USA)). 1975. 7p. TIC.

The location of the gravity base station for Gerlach and San Emidio, Nevada gravity surveys is described. Site data and gravity data are given.

**4689** **Regional heat flow as an indicator of geothermal resources (abstract).** Sass, J.H.; Lachenbruch, A.H.; Munroe, R.J. (Geological Survey, Menlo Park, CA). *Geol. Soc. Am., Abstr. Programs;* **6**: No. 3, 247(Feb 1974).

From 70. annual meeting of the Cordilleran section of the Geological Society of America; Las Vegas, NV, USA (29 Mar 1974).

**4690** **Geothermal studies in north-central Nevada (abstract).** Wollenberg, H.A. (Univ. of California, Berkeley). *Geol. Soc. Am., Abstr. Programs;* **6**: No. 7, 1009(Oct 1974).

From 1974 annual meetings of the Geological Society of America; Miami Beach, FL, USA (18 Nov 1974).

**4691** **Rotating-field resistivity surveys for geothermal exploration (abstract).** Keller, G.V.; Tasci, T.; Morris, A. (Colorado School of Mines, Golden). *Am. Assoc. Pet. Geol. Bull.;* **59**: No. 5, 913(May 1975).

From Conference on Rocky Mountain energy resources: discovery and development; Albuquerque, NM, USA (1 Jun 1975).

Dipole mapping surveys are used frequently in reconnaissance exploration for geothermal systems. In the conventional single-source dipole mapping survey, current is fed to the ground through a fixed pair of electrodes. The electric-field intensity around the electrodes is then mapped to locate distortions caused by the presence of low resistivity rocks such as are associated with

geothermal systems. However, not all areas of low electric-field intensity are caused by low resistivities; some are geometric effects at boundaries between areas with different resistivities. A solution to the problem of recognizing such "false" anomalies is provided by making two sets of dipole measurements with two sources oriented at right angles to one another. Then, resistivity can be computed as a function of the direction of current flow by combining the two sources in various ways. Examples of rotating-field resistivity surveys over geothermal prospects in Hawaii and Nevada are given.

**4692 Terrestrial heat flow in northeastern New Mexico and southeastern Colorado (abstract).** Edwards, C.L.; Reiter, M.A.; Shearer, C.R. (New Mexico Inst. of Mining and Tech., Socorro). *Am. Assoc. Pet. Geol. Bull.;* **59**: No. 5, 908(May 1975).

From Conference on Rocky Mountain energy resources: discovery and development; Albuquerque, NM, USA (1 Jun 1975).

**4693 Geothermal studies in region of isolated hot springs in western Montana (abstract).** Chadwick, R.A. (Montana State Univ., Bozeman). *Am. Assoc. Pet. Geol. Bull.;* **59**: No. 5, 906-907(May 1975).

From Conference on Rocky Mountain energy resources: discovery and development; Albuquerque, NM, USA (1 Jun 1975).

**4694 Geothermal resistivity investigations in New Mexico (abstract).** Jiracek, G.R.; Smith, C.S.; Forsythe, G.T.; Dorn, G.A. (Univ. of New Mexico, Albuquerque). *Am. Assoc. Pet. Geol. Bull.;* **59**: No. 5, 913(May 1975).

From Conference on Rocky Mountain energy resources: discovery and development; Albuquerque, NM, USA (1 Jun 1975).

**4695 Terrestrial heat-flow studies in eastern Arizona and western New Mexico (abstract).** Shearer, C.R.; Reiter, M.A.; Edwards, C.L. (New Mexico Inst. of Mining and Tech., Socorro). *Am. Assoc. Pet. Geol. Bull.;* **59**: No. 5, 923(May 1975).

From Conference on Rocky Mountain energy resources: discovery and development; Albuquerque, NM, USA (1 Jun 1975).

**4696 Use of earth resources technology satellite: aeromagnetic, gravity, and thermal data for mapping potential geothermal resources (abstract).** Lepley, L.K.; Doss, A.K. *Am. Assoc. Pet. Geol. Bull.;* **59**: No. 5, 915(May 1975).

From Conference on Rocky Mountain energy resources: discovery and development; Albuquerque, NM, USA (1 Jun 1975).

**4697 Seismic refraction study in the Raft River geothermal area, Idaho (Abstract).** Ackermann, H.D. (Geological Survey, Denver). *Geophysics;* **41**: No. 2, 336(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4698 Passive and active seismic studies and the geologic structure of the Boise Front, Idaho (Abstract).** Applegate, J.K.; Donaldson, P.R. *Geophysics;* **41**: No. 2, 339(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4699 Systematic program for geothermal exploration on the Island of Hawaii (Abstract).** Furumoto, A.S. (Univ. of Hawaii, Honolulu). *Geophysics;* **41**: No. 2, 352-353(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4700 Regional gravity survey of the Beluga Basin and adjacent areas, Cook Inlet Region, South-Central Alaska (Abstract).** Hackett, S.W. (Dept. of Natural Resources, College, Alaska). *Geophysics;* **41**: No. 2, 354-355(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4701 Capillary pressure potential: a significant source of error in self-potential measurements (Abstract).** Hoover, D.B. (Geological Survey, Denver). *Geophysics;* **41**: No. 2, 356-357(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4702 Telluric—magnetotelluric method: separating near-surface inhomogeneities from deep-seated geothermal anomlies (Abstract).** Hermance, J.F. (Brown Univ., Providence). *Geophysics;* **41**: No. 2, 355-356(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4703 Exploration for geothermal reservoirs (Abstract).** Keller, G.V.; Furgerson, R.B.; Crewdson, R.A. (Colorado School of Mines, Golden). *Geophysics;* **41**: No. 2, 359-360(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4704 Geothermal energy multiband concept for aerial geothermal prospecting (Abstract).** Del Grande, N.K. (Univ. of California, Livermore). *Geophysics;* **41**: No. 2, 348-349(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4705 Reconnaissance geophysics of known geothermal resource area, Wiser, Idaho, and Vale, Oregon (Abstract).** Long, C.L.; Kaufmann, H.E. (Geological Survey, Denver). *Geophysics;* **41**: No. 2, 363(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4706 Reconnaissance geothermal exploration at Raft River, Idaho from thermal infrared scanning (Abstract).** Watson, K. (Geological Survey, Lakewood, CO). *Geophysics;* **41**: No. 2, 380(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4707 Exploring the Raft River geothermal area, Idaho, with the dc resistivity method (Abstract).** Zohdy, A.A.R.; Jackson, D.B.; Bisdorf, R.J. (Geological Survey, Denver). *Geophysics;* **41**: No. 2, 382(Apr 1976).

From 45. annual SEG meeting; Denver, CO, USA (12 Oct 1975).

**4708 Geologic and seismic studies of Boise Front, Idaho, for geothermal resource evaluation (Abstract).** Applegate, J.K.; Donaldson, P.R.; Mink, L.L. (Boise State Univ., ID). *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1389(Aug 1976).

From 25. annual meeting AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

**4709 Heat-flow study of Snake River Plain, Idaho (Abstract).** Brott, C.A. (Southern Methodist Univ., Dallas). *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1392(Aug 1976).

From 25. annual meeting of AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

**4710 Geoelectrical investigations of Boise, Idaho, geothermal system (Abstract).** Donaldson, P.R.; Applegate, J.K. (Boise State Univ., ID). *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1397(Aug 1976).

From 25. annual meeting of AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

**4711 Heat-flow studies in Steamboat Mountain—Lemei Rock Area, Skamania County, Washington (Abstract).** Schuster, J.E. (Dept. of Natural Resources, Olympia, WA); Blackwell, D.D.; Hammond, P.E.; Huntting, M.T. *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1410(Aug 1976).

From 25. annual meeting of AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

## GEOCHEMICAL TECHNIQUES AND SURVEYS

*REFER ALSO TO CITATION(S) 4687, 4690*

**4712 (USGS-OFR—75-427) Helium surveys over known geothermal resource areas in the Imperial Valley, California.**

Roberts, A.A. (Geological Survey, Reston, Va. (USA)). 1975. 8p. TIC.

The concentration of helium in the soil gas was measured over the Dunes, East Mesa, Brawley and Salton Sea geothermal areas. The good correlation observed between the helium concentration (in ppM) and the temperature gradients in these areas is illustrated graphically. This strongly supports the possible utility of helium sniffing as a quick, inexpensive tool for geothermal reservoir prospecting.

**4713 Chemical properties of some of the major hot springs of northern Nevada (abstract).** Mariner, R.H.; Presser, T.S.; Rapp, J.B.; Willey, L.M. (Geological Survey, Menlo Park, CA). *Geol. Soc. Am., Abstr. Programs;* **6**: No. 3, 214(Feb 1974).

From 70. annual meeting of the Cordilleran section of the Geological Society of America; Las Vegas, NV, USA (29 Mar 1974).

**4714 Geothermal studies in Alaska (abstract).** Barnes, I. (Geological Survey, Menlo Park, CA); Miller, T.P. *Geol. Soc. Am., Abstr. Programs;* **6**: No. 7, 645(Oct 1974).

From 1974 annual meetings of the Geological Society of America; Miami Beach, FL, USA (18 Nov 1974).

**4715 Investigations of the hydrology of the Imperial Valley geothermal area using stable isotopes (abstract).** Coplen, T.B. (Univ. of California, Riverside). *Geol. Soc. Am., Abstr. Programs;* **6**: No. 7, 694(Oct 1974).

From 1974 annual meetings of the Geological Society of America; Miami Beach, FL, USA (18 Nov 1974).

**4716 Leach Hot Springs geothermal area, Nevada (abstract).** Olmstead, F.H. (Geological Survey, Menlo Park, CA); Van Denburgh, A.S. *Geol. Soc. Am., Abstr. Programs;* **6**: No. 7, 899(Oct 1974).

From 1974 annual meetings of the Geological Society of America; Miami Beach, FL, USA (18 Nov 1974).

**4717 Carbon isotope composition of soil gases as an indicator of geothermal areas (abstract).** Rightmire, C.T.; Truesdell, A.H. (Geological Survey, Reston, VA). *Geol. Soc. Am., Abstr. Programs;* **6**: No. 7, 927(Oct 1974).

From 1974 annual meetings of the Geological Society of America; Miami Beach, FL, USA (18 Nov 1974).

**4718 Radiologic considerations in development of geothermal resources in western United States (abstract).** Kaufmann, R.F.; O'Connell, M.F. (Environmental Protection Agency, Las Vegas, NV). *Am. Assoc. Pet. Geol. Bull.;* **59**: No. 5, 913(May 1975).

From Conference on Rocky Mountain energy resources: discovery and development; Albuquerque, NM, USA (1 Jun 1975).

**4719 Application of chemical geothermometers to thermal waters of southwest New Mexico and West Texas (abstract).** Swanberg, C.A. (New Mexico State Univ., Las Cruces). *Am. Assoc. Pet. Geol. Bull.;* **59**: No. 5, 924(May 1975).

From Conference on Rocky Mountain energy resources: discovery and development; Albuquerque, NM, USA (1 Jun 1975).

### EXPLORATORY DRILLING AND WELL LOGGING

**4720 Raft River, Idaho, geothermal wells: siting, drilling, and testing (Abstract).** Stoker, R.C.; Kunze, J.F.; Miller, L.G. (Idaho National Engineering Lab., Idaho Falls). *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1411(Aug 1976).

From 25. annual meeting of AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

## LEGAL AND INSTITUTIONAL ASPECTS

**4721** (MTR—7137) **Geothermal energy resource utilization program planning.** Grover, F.T. (Mitre Corp., McLean, Va. (USA)). Mar 1976. Contract E(11-1)-2693. 44p. (COO/2693—76/1). Dep. NTIS $4.00.

ERDA's basic strategy for creating alternative energy supplies is to conduct a program of research, development, and demonstration of energy technology which induces and aids private exploitation of, in this case, geothermal energy resources (commercialization). So that the existence of (user) choice is demonstrated, and as a means of channelizing efforts for the mitigation of the nation's gathering crisis in energy supply, specific commercialization goals have been set by ERDA. A procedure is described for planning the achievement of the commercialization goals established for geothermal energy resources. It has been prepared for the consideration of the Office of Resource Utilization, of ERDA's Division of Geothermal Energy.

**4722 Lease of federal geothermal energy: rocky road (abstract).** Stark, D. (Bureau of Land Management, Billings, MT). *Am. Assoc. Pet. Geol. Bull.;* **60**: No. 8, 1410(Aug 1976).

From 25. annual meeting of AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

**4723 Legal issues in the development of geopressured geothermal resources of Texas and Louisiana Gulf Coast (Summary).** Elmer, D.B. (Univ. of Texas, Austin). *Geotherm. Energy Mag.;* **4**: No. 9, 13-19, 22-25, 27-28, 30-33, 35-38(Sep 1976).

Two major topics, legal scholarship and legal support, are covered. Scholarship is distinguished from support by concentration on abstract analyses of issues, which include resource definition, ownership, taxation, and multistate reservoirs. Support is based entirely on those legal tasks called up by the technical work scheduled in the areas of resource assessment, advanced research and technology, institutional and environmental and resource utilization. The definitions contained in the statutes of the thirteen western states, Texas, and Louisiana are presented. (MHR)

## ECONOMIC AND FINANCIAL ASPECTS

*REFER ALSO TO CITATION(S) 4676*

## ENVIRONMENTAL ASPECTS

*REFER ALSO TO CITATION(S) 4718*

**4724** (USGS-OFR—75-637) **Potential effects of geothermal development on springs at the Hot Creek Fish Hatchery in Long Valley, Mono County, California.** Sorey, M.L. (Geological Survey, Reston, Va. (USA)). 1976. 15p.

Springs at the Hot Creek Fish Hatchery in the Long Valley caldera, Mono County, California, supply 570 l/s (9000 gal/min) of water at a composite temperature of 14.4°C (57.9°F), which is near optimum for production of trout. Geochemical data and temperature profiles in shallow test holes indicate that from 1 to 3 percent of the discharge in the Hatchery springs is contributed by the hot-water system at depth. Because geothermal development may eventually cause pressure declines in the hot-water reservoir over much of the caldera, the hot-water component in the Hatchery springs could be eliminated. This would not noticeably alter the rate of discharge, but could lower the composite spring temperature to about 11°C (52°F). Such a temperature drop would cause a decrease in the productivity of the Hatchery, although the magnitude of the effect has not been determined. In addition, the time required for any geothermal development to so affect the Hatchery will depend on as yet unknown factors such as distance to centers of production, production rates, a hydraulic characteristics of the hot-water reservoir.

## BY-PRODUCTS

**4725** (PB—241867) **Process technology for recovering geothermal brine minerals.** Berthold, C.E.; Hadzeriga, P.; Christopher, D.H.; Applegate, T.A.; Gillespie, D.M. (Hazen Research, Inc., Golden, Colo. (USA)). 4 Feb 1974. Contract S0133084. 255p. NTIS $8.50.

Geothermal fluids and hot springs waters from California and Nevada were sampled and analyzed to provide a basis for process development and economic studies on the potential for recovering valuable minerals from these fluids. In general, bulk precipitation methods were used to remove the valuable constituents from the geothermal fluids, followed by separation of the constituents from this bulk precipitate. Concentration of geothermal fluids to recover soluble saline constituents such as sodium chloride and calcium chloride does not appear practical, owing primarily to the probable need for reinjecting such fluids back into the production zone. (GRA)

## GEOTHERMAL POWER PLANTS

*REFER ALSO TO CITATION(S) 4676*

### POWER PLANT SYSTEMS AND COMPONENTS

*REFER ALSO TO CITATION(S) 4726*

## GEOTHERMAL ENGINEERING

### DRILLING TECHNOLOGY AND WELL HARDWARE

*REFER ALSO TO CITATION(S) 4720*

### CORROSION, SCALING, AND MATERIALS DEVELOPMENT

**4726** (UCID—17170) **Boundary-layer control for reducing deposition of solids at a geothermal nozzle wall.** Homsy, R.V. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 10 Jun 1976. Contract W-7405-Eng-48. 15p. Dep. NTIS $3.50.

Deposition of solids at the wall of a nozzle used to expand geothermal brine may be accounted for by a hydrodynamic model describing eddy formation near the wall. A conceptual design of a nozzle with injection of an annular ring of fluid at the wall is presented.

**4727** (UCID—17209) **LLL Geothermal Industrial Support Program in chemistry and materials for FY76T and FY77.** Quong, R. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 29 Jul 1976. Contract W-7405-Eng-48. 23p. Dep. NTIS $3.50.

A proposed program is outlined covering the following areas: scale characterization and control, brine and effluent characterization, suspended solids characterization and control, effluent condition for reinjection, corrosion surveillance and Geothermal Loop Experimental Facility support, and materials testing and evaluation. (MHR)

### GEOTHERMAL RESERVOIR AND WELL PERFORMANCE

**4728** **Geothermal steam roars.** Shapiro, D. *Geotherm. Energy Mag.;* 4: No. 9, 39-40 (Sep 1976).

A successful four-hour flashing of Hawaii's first geothermal test well is described. The results of this test are discussed. (MHR)

## GEOTHERMAL DATA AND THEORY

### PROPERTIES OF AQUEOUS SOLUTIONS

**4729** (LBL—5227) **Establishment of a computer data base on geothermal properties of aqueous NaCl, KCl, and $CaCl_2$ solutions.** Fair, J.A.; Phillips, S.L. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Jul 1976. Contract W-7405-Eng-48. 24p. (CONF-760643—5). Dep. NTIS $3.50.

From 5. CODATA conference; Boulder, Colorado, United States of America (USA) (28 Jun 1976).

The physical chemistry category of the Geothermal Informance Resource (GRID) is discussed with emphasis on the need for improvement in the data available. The discussion is limited to aqueous solutions. (MHR)

**4730** (USGS-OFR—75-675) **Preliminary "steam tables" for NaCl solutions. Thermodynamic properties of the coexisting phases and thermochemical properties of the NaCl component.** Haas, J.L. Jr. (Geological Survey, Reston, Va. (USA)). Oct 1975. 68p. TIC.

Preliminary "steam tables", which give the thermodynamic data for the coexisting liquid and gas and the thermochemical data for the NaCl component in the liquid for the system $H_2O$-NaCl, are given for liquid concentrations between 0 mol NaCl/kg $H_2O$ and halite saturation at temperatures between 80° and 325°C. The tables were calculated from parametric equations of state.

**4731** **Variations on a theme by Mollier (a study of the properties of steam and hot water).** Armstead, H.C. *Geotherm. Energy Mag.;* 4: No. 8, 19-38(Aug 1976).

The "state" of steam, hot water, and steam/water mixtures can be expressed in terms of the following five interdependent variables: pressure, temperature, dryness, enthalpy, and entropy. If any two of these variables are selected as rectangular coordinates of a chart, the other three variables may be represented on that chart by a series of curves. There are ten possible pairs of coordinates, and thus ten possible forms of chart, which can represent the thermodynamic properties of steam and hot water. Each of the ten possible charts is discussed in turn and illustrated. (MHR)

### PROPERTIES OF MINERALS AND ROCKS

**4732** (UCRL—77938) **Model for the prediction of the pressure-volume relationship of porous rocks.** Abey, A.E. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 20 Jul 1976. Contract W-7405-eng-48. 7p. (CONF-760824—1). Dep. NTIS $3.50.

From 17. symposium on rock mechanics; Snowbird, Utah, United States of America (USA) (25 Aug 1976).

Several models have been suggested to describe the volume behavior of porous materials under hydrostatic loading. The model presented here accounts for variations in both porosity and the amount of fluid contained within that porosity. The model also attempts to predict the one-dimensional strain loading pressure-volume relationship and the stress difference-confining pressure curve. Only the simplest assumptions were used for the development of this model. These assumptions are discussed and the predictions for Mt. Helen tuff are compared to experimental data.

### ROCK-WATER-GAS INTERACTIONS

**4733** (USGS-OFR—75-649) **Chemical characteristics of hydrothermal alteration at Bingham, Utah.** Moore, W.J. (Geological Survey, Reston, Va. (USA)). 1975. 18p. TIC.

The Bingham area is considered in relation to other areas of base metallization (Park City, Cottonwood, American Fork, Stockton, Ophir) in north-central Utah. The Bingham area in the east-central Oquirrh Mountains is only one of a number of mid-Tertiary (Eocene-Oligocene) intrusive centers associated with volcanic rocks of similar age and composition. The northeasterly alignment of stocks and ae..magnetic anomalies is commonly referred to as the "Uinta Trend." The Bingham and Last Chance stocks intruded by latitic dikes that may, in part, represent feeders for generally coeval lavas of similar composition preserved along the eastern flanks of the Oquirrh Mountains are mapped. Mineralogical and chemical features of the two major intrusive phases in the stock are discussed.

# WIND ENERGY

## AVAILABILITY (CLIMATOLOGY)

**4734** (SAND—76-5397) **Predicting wind power at turbine level from an anemometer record at arbitrary height.** Reed, J.W. (Sandia Labs., Albuquerque, N.Mex. (USA)). 1976. Contract AT(29-1)-789. 10p. (CONF-760909—1). Dep. NTIS $3.50.

From International symposium on wind energy systems; Cambridge, United Kingdom of Great Britain and Northern Ireland (UK) (7 Sep 1976).

Wind speed variation with height in the frictional boundary layer depends on wind speed, surface roughness and thermodynamic stability. Over relatively flat terrain, suitable for extensive fields of wind energy extractors, useful wind increases in proportion to the one-seventh power of height above ground. This closely approximates the more general and theoretically based logarithmic model above standard 10 meter anemometer height and with the 0.03m roughness length often found by observation. Several data collections have been assembled to verify the utility of this one-seventh power law, from special meteorological research towers as well as long-term records from regular weather stations where the anemometer happened to be moved on occasion. A minor correction for lower speeds of 2—8m/s improves predictions but is not essential to gross power availability calculations for large turbine blades.

**4735** (UCRL—50034-76-3) **Wind power studies: field measurement priorities for numerical analysis of wind energy. Progress report, April—June 1976.** Hardy, D.M. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 15 Jun 1976. Contract W-7405-eng-48. Dep. NTIS $3.50.

Results of initial numerical studies and their role in planning the July—August 1976 field program are presented. The acquisition, calibration, and deployment of meteorological instruments for the field program are reviewed.

## WIND ENERGY ENGINEERING

**4736** (N—75-21796) **Wind power installations. Present condition and possible lines of development.** Fateev, Y.M. Mar 1975. Translation of Vetrosilovye Ustanovki Sosttoyanie i Puti Razvitiya, Moscow, 1959. (NASA-TT-F—16204). 80p. NTIS $4.75.

Wind power is discussed as a source of energy, past, present and future. A brief summary of the history and development of windmills is presented. Tables of average wind velocity are included for different zones in the U.S.S.R. compiled from meteorological stations over a period of years. It is shown that the development of highly efficient wind power theory and engineering has led to the development of highly efficient wind-driven motors which use up to 42% of wind energy. The agricultural uses of wind-driven motors are also discussed. The matching of piston and centrifugal use of millstones with wind-driven motors are included. The use of free and unlimited wind energy is concluded to be efficient, particularly in agricultural and rural areas. (auth)

**4737** (N—75-22904) **Wind engines and wind installations.** Fateev, Y.M. Mar 1975. Translation of Vetrodvigateli i Vetroustanovki, State Publishing House of Agricultural Literature, Moscow, 1948. (NASA-TT-F—16170). 391p. NTIS $10.25.

A comprehensive theoretical treatment of aerodynamics is presented along with a description of windtunnels, the aerodynamic characteristics of wind engines, towers, and related equipment. Methods of adjustment of wind engines to the wind are described along with several ways of regulating the number of revolutions and the power of wind engines. Wind energy, anemographs, wind engines working with piston and centrifugal pumps, and various agricultural machines are discussed along with windmills and windpower stations. (Auth)

# ELECTRIC POWER ENGINEERING

## POWER GENERATION

### COOLING SYSTEMS

*REFER ALSO TO CITATION(S) 5037*

**4738** (MIT-EL—75-023) **Advanced dry cooling tower concept.** Curcio, J.; Giebler, M.; Glicksman, L.R.; Rohsenow, W.M. (Massachusetts Inst. of Tech., Cambridge (USA)). 30 Sep 1975. Contract E(11-1)-2500. 113p. Dep. NTIS $5.50.

The purpose of the studies reported has been to develop a new dry cooling tower surface. The new surface utilizes a modification of film type packing in wet cooling towers. It is a concept which may eliminate excessive water loss. Cost of fabrication, and effectiveness of heat transfer surface were among the major design considerations. Based on preliminary water wetting investigations over simple geometric surfaces, a conductive plate was shaped to form a series of V-troughs. It provided open channelled water flow separated by fin-like dry surfaces, and simultaneously self distributed random spraying water. The design not only channels the water flow, but also provides a convenient means to vary the air-water interfacial area to the water-plate and dry plate contact area. To investigate the effectiveness of this design and of future advanced wet-dry concepts, a model heat transfer test apparatus was constructed. A computer simulation of the proposed surface was made. The simulation modeled heat and mass transfer from the air-water interface as well as heat transfer from the dry surface area. Initial parametric runs were made using the program. They indicate that when the ratio of wet surface area to total surface area is five percent, approximately seventy-five percent of the energy transfer takes place as sensible heat transfer; whereas, for a wet tower at similar conditions approximately eighty-five percent of the total energy transfer takes place by evaporation.

**4739** (PB—242406) **External roughness effects on the mean wind pressure distribution on hyperbolic cooling towers.** Farell, C.; Maisch, F.E. (Iowa Inst. of Hydraulic Research, Iowa City (USA)). Aug 1974. 60p. (IIHR—164). NTIS $4.25.

Prepared in cooperation with Marley Co., Mission, Kans.

The effect of external, concentrated roughness elements or ribs on the mean pressure distributions on model hyperbolic cooling towers in uniform wind was experimentally investigated in the 5-foot low-turbulence wind tunnel of the IIHR. Several longitudinal rib configurations were tested, varying systematically rib height, rib width, and rib spacing. Three uniformly distributed, or random, roughnesses were also tested for purposes of comparison. (GRA)

**4740** **Dry cross-flow cooling tower.** Fordyce, H.E. (to Marley Co.). German(FRG) Patent 2,431,851/A/. 23 Jan 1975. 60p. (In German).

19 figs.

The invention deals with dry cooling towers in particular a circular cooling tower of the mechanical-draught construction whose operating characteristics should be independent of the wind direction. The recycling of the hot air should be as low as possible without necessitating high fan or natural-draught shafts, so that the costs of the tower can be brought down to a minimum.

**4741** **Water cooling tower.** Cates, R.E. (to Marley Co.). German(FRG) Patent 2,443,589/A/. 15 May 1975. 57p. (In German).

9 figs.

A water cooling tower is described which has indirect vaporizing heat exchangers arranged at a distance from one another in order to sink its temperature. A device feeds the hot water into the heat exchangers in order to conduct it through these in series. The heat exchangers have inlets for the environmental air and outlets for the hot air.

### COMBINED AND BINARY CYCLES

*REFER ALSO TO CITATION(S) 4379, 5235*

### POWER PLANT COMPONENTS

*REFER ALSO TO CITATION(S) 4997, 5255, 5256*

**4742** **Fire protection for steam power generating plants.** Coon, W. *Power Eng.*; **80**: No. 6, 68-71(Jun 1976).

The major fire hazards found in a fossil-fuel power plant include unprotected floor openings, unenclosed fire hazard areas, liquid and solid fuel storage and handling equipment, transformers, and cooling towers plus dust collectors, cable runs, and gas turbine generators. Therefore, a total concept approach to fire protection is recommended which employs a full design team and a fire protection engineer working at the plant design stage. (LCL)

### WASTE HEAT UTILIZATION

*REFER ALSO TO CITATION(S) 5167*

### ECONOMICS

**4743** **Retail electric bills and rate changes.** *Fed. Regist. (Wash., D.C.)*; **41**: No. 135, 28904-28905(13 Jul 1976). (18CFR141).

From Conservation of Power and Water Resources, 18CFR141, Federal Power Commission—Report on retail electric bills and rate charges. New FPC Form No. 159.

Notice is hereby given pursuant to the Administrative Procedure Act, 5 U.S.C. 553, and sections 10, 19, 20, 202, 205, 206, 207, 304, 309 and 311 of the Federal Power Act, that the Commission proposes to add Section 141.32 to Part 141 of the Approved Forms under the Federal Power Act to provide that a new FPC Form No. 159 be required for reporting. The proposed new form would be entitled "Report on Retail Electric Bills and Rate Changes."

## ENVIRONMENTAL ASPECTS

### NOXIOUS GAS CONTROL

*REFER ALSO TO CITATION(S) 5296, 5300, 5479*

**4744** (PB—241756) **Maximum $SO_2$ concentrations produced by a 1000-megawatt power plant. Final report.** (Enviroplan, Inc., Rutherford, N.J. (USA)). Apr 1975. Contract EPA-68-01-2837. 75p. NTIS $4.25.

The objective of the study given was to predict the largest annual average sulfur dioxide ($SO_2$) concentrations, maximum 24-hour $SO_2$ concentrations, and maximum 3-hour $SO_2$ concentrations produced per year by a new modern 1000 megawatt electric power plant that complies with the federal New Source Performance Standards for $SO_2$ emissions from coal-fired power plants. The prediction evidence from this study is intended for use in final decisions by the U.S. Environmental Protection Agency concerning federal standards to be promulgated on the subject of nondegradation of air quality. A total of three plant alternatives for complying with new source standards were examined: the use of a scrubber, the use of a scrubber with reheat of emissions, and the use of low sulfur coal.

**4745** (PB—241918) **Analysis of test data for NO/sub x/ control in gas- and oil-fired utility boilers. Final report, 1 May 1973—31 Aug 1974.** Dykema, O.W. (Aerospace Corp., El Segundo, Calif. (USA). Urban Programs Div.). Jan 1975. 260p. (ATR—75(7487)-1). NTIS $8.50.

The report describes analyses of a large number of emissions, operating conditions, and boiler configuration data from full-

scale, multiple-burner electric utility boilers using natural gas and low-sulfur oil fuels. The report includes: (1) a discussion of the major combustion process modications resulting in NOx emission reductions due to two-stage combustion, burners out-of-service, combustion air temperature reduction, load reduction, and excess air variations; (2) estimates of NOx minima achievable in the boilers studied with current hardware; (3) estimates of most probable longer term hardware and operating condition modifications likely to yield ultimate NOx reductions with these fuels; (4) identification and verification of general mechanisms for the combustion and flame instabilities observed; and (5) a list of all of the hardware configurations, operating conditions, and NOx, CO, $O_2$, and $CO_2$ emissions data for 428 tests in eight full-scale, multiple-burner, face-fired electric utility boilers using natural gas and low-sulfur oil fuels. (GRA)

**4746** (PB—242515) **Investigation of extractive sampling interface parameters. Final report.** McNulty, K.J.; McCoy, J.F.; Becker, J.H.; Ehrenfeld, J.R.; Goldsmith, R.L. (Abcor, Inc., Cambridge, Mass. (USA). Walden Research Div.). Oct 1974. Contract EPA-68-02-0742. 191p. NTIS $7.00.

The results are presented of a twelve month, three-phase investigative program with the intent of providing EPA with sufficient information to permit the establishment of minimum specifications for the design of continuous extractive sample interface systems. An extractive sampling interface system is the equipment associated with an instrumental source measurement system which extracts, transports, and conditions a sample of the source effluent. The work was directed toward an investigation of interface systems for use on Category I sources for the following instrumental techniques: (1) non-dispersive infrared analyzers, (2) ultra-violet analyzers, (3) electrochemical sensors, and (4) chemiluminescent analyzers. Both laboratory and field results are reported.

## POWER TRANSMISSION AND DISTRIBUTION

**4747** (BDX—613-1421) **Detection and control of power-line transients affecting tester and gage performance.** Hill, J.W. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 16p. Dep. NTIS $3.50.

Certain indications of product failure obtained from product testers have been suspected to be the result of short-duration power-line transients. A project is described which was initiated to monitor power lines and thus determine the type of transients that are most prevalent, to perform transient-immunity tests on product testers and other sensitive instruments, and to make a survey of transient-protection methods that might be adopted. A Programmed Power Inc. Model 3200 power-line monitor was rented and evaluated. It performed all functions within specifications, but it proved to be subject to errors caused by power-line transients in its own power input. The monitoring of power lines indicated that common transients were small in amplitude, with peaks of 50 volts, or less. Electrical storms were found to produce large numbers of transients with peaks exceeding 100 volts. Transient-immunity tests were performed on several product testers. Those that were Bendix-built proved to be immune to transients with peaks exceeding 600 volts, while those purchased from outside sources were sensitive to transients with peaks in the 100 to 250 volt range. Recommendations for the control of transient problems include routine verification of transient-immunity for product testers and other instruments, the use of transient suppressors as insurance against large transients, and the acquisition of equipment for a permanent transient-monitoring capability.

### SUPERCONDUCTING AND CRYOGENIC SYSTEMS

*REFER ALSO TO CITATION(S) 5531*

**4748** (BNL—21666) **Instrumentation requirements for long superconducting power transmission lines.** Jensen, J.E. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 9p. (CONF-761007—4). Dep. NTIS $3.50.

From Conference on productivity through instrumentation and control; Houston, Texas, United States of America (USA) (10 Oct 1976).

Two studies of possible applications of long superconducting power transmission lines are presented to illustrate instrumentation requirements and attendant problems. These studies serve to show the types of equipment, logistics, and environmental factors affecting the instrumentation. The parameters requiring measurement are discussed along with indications of how the data acquired will be used in control, diagnostics, and safety of the cryoelectric system.

**4749** **European progress in cryopower transmission.** Bogner, G. (Siemens, Erlangen, Ger). *Adv. Cryog. Eng.*; **19**: 78-91(1974).

A number of ac and dc superconducting cable projects presently exist in Europe. Special attention is being focused on semiflexible cable types, i.e., with rigid cryogenic envelopes in which flexible conductors are contained. In addition, totally flexible cables are being developed which enclose flexible conductors in flexible cryogenic jackets constructed with the aid of corrugated tubes. Intensive investigations of the properties of thermal insulations, stabilized superconductors, and electrical insulations have been carried out and are being continued. Special manufacturing processes for niobium-copper or niobium-aluminum ac composite conductors have been developed.

**4750** **Research on a laboratory model of superconducting test cable.** Razevig, D.V.; Blinkov, Y.L.; Goldenberg, Y.S. (Power Research Inst., Moscow). *Adv. Cryog. Eng.*; **19**: 92-100(1974).

The Power Research Institute in Moscow has constructed the first laboratory model of a single-phase superconducting cable which operated in a semiopen circuit. Components of the system included a gas holder, refrigerator, and superconducting cable with niobium superconductor. The cable was energized by both ac and dc. The laboratory model verified the possibility of attaining the design current density in the superconductor with forced coolant circulation, and provided information on the efficiency and stability of the model's components.

**4751** **Development of a rigid ac superconducting power transmission line.** Meyerhoff, R.W. (Union Carbide Corp., Tarrytown, NY). *Adv. Cryog. Eng.*; **19**: 101-108(1974).

This presentation summarizes recent work on the development of the conductor and dielectric systems for the proposed rigid coaxial system having a power rating of 3400 Mva. The proposed ac superconducting power transmission line consists of three-phase conductors each mounted by means of dielectric spacers coaxially within its own superconducting shield.

## NUCLEAR POWER PLANTS

*REFER ALSO TO CITATION(S) 5190*

**4752** (LBL—5206) **Guidebook to nuclear reactors.** Nero, A.V. Jr. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). May 1976. Contract W-7405-ENG-48. 134p. Dep. NTIS $6.00.

A general introduction to reactor physics and theory is followed by descriptions of commercial nuclear reactor types. Future directions for nuclear power are also discussed. The technical level of the material is suitable for laymen.

**4753** **Nuclear power reactors: the importance of being right.** Fishlock, D. *Des. Eng. (London)*; 6-7, 9, 11, 13(Sep 1974).

The British nuclear energy 'engineering disaster' of the past decade, the contentious debate that followed, and the prospects for the future, are considered. It is claimed that the UK nuclear industry lacks leadership and that this fact alone poses more risk to forecasts for 1984 than the new technical troubles likely to be encountered in the next ten years.

**4754** **Nuclear future.** *Esso Mag.*; No. 96, 8-12(1975).

A short account is given of the development of nuclear power and of the technical and other problems that have been met. It is concluded that although work is in progress on nuclear fusion, the hope of independence from fossil fuels lies for the next few decades in the development of efficient, safe and economical nuclear fission techniques. It is stated that these are techniques in which engineers, planners, financiers and industrialists are beginning to excel.

**4755** **Cooperation between economy, science, and the state, demonstrated on the example of the Fourth Atomic Energy Program of the German Federal Republic and the basic energy research program.** Lehr, G. (Bundesminist fuer Forsch und Technol, Bonn). *Schweissen Schneiden;* **27**: No. 2, 45-49(Feb 1975). (In German).

This paper was presented at the Colloquium on 'Welding in Nuclear Engineering' at Duesseldorf in 1974, the Colloquium itself being considered an example of the cooperation described.

**4756** **Development trends and possibilities in the technology of nuclear energy.** Levai, A. (Tech. Univ., Budapest). *Oesterr. Ing.-Z.*; **18**: No. 3, 72-77(Mar 1975). (In German).

**4757 Nuclex technical sessions. Report from Basel.** *Nucl. Eng. Int.;* **20**: No. 237, 1025-1026(Dec 1975).

A brief review is presented of some highlights from the papers given at the Nuclex exhibition in Basel, October 1975, which were considered to be particularly relevant to current problems in the world nuclear industry. The review concentrates on the problem of leakage in steam generators for PWRs, experience with early Magnox and AGR stations, the final design of the SGHWR, the status of the Russian 600 MW BN-600, and safety in FBR reactors.

**4758 How Westinghouse is consolidating its international lead.** *Nucl. Eng. Int.;* **20**: No. 237, 999-1007(Dec 1975).

The second of a series of profiles of major industrial groups in the world's nuclear industry, examines the attitudes and objectives of some of the executives now responsible for directing the widespread and complex international nuclear business of the Westinghouse Electric Corporation. Against the background of new management thinking in the group, the article discusses the significance of the emphasis on plant standardization of reliability, and on productivity in manufacturing.

**4759 Need for awareness of inservice inspection requirements.** Dau, G.J. (Electric Power Research Inst., Palo Alto, CA). *Trans. Am. Nucl. Soc.;* **23**: 180(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4760 Future of the U.S. nuclear energy industry.** Joskow, P.L.; Baughman, M.L. (Univ. of Texas, Austin). *Trans. Am. Nucl. Soc.;* **23**: 189(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## POWER REACTORS, NON-BREEDING, LIGHT-WATER MODERATED, BOILING WATER COOLED

*REFER ALSO TO CITATION(S) 4781, 4929, 4932, 5036, 5080, 5100, 5102, 5104, 5113, 5118, 5119, 5120, 5133, 5142, 5146, 5149, 5151*

**4761 Effect of corrosion products in the primary circuit of light water in nuclear power plants.** Kamelander, G. (Oesterr Studienges fuer Atomenerg, Vienna). *Oesterr. Ing.-Z.;* **18**: No. 2, 44-46(Feb 1975). (In German).

**4762 Analytical techniques employed in reactor fuel handling and storage-related nuclear criticality analyses.** Harding, R.S.; Klotz, R.J.; Noderer, L.C.; Rosenthal, J.E. (Combustion Engineering, Inc., Windsor, CT). *Trans. Am. Nucl. Soc.;* **23**: 583(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4763 High-density spent-fuel storage rack design for boiling water reactors.** Allison, M.M.; Denver, D.J.; Slifer, B.C. (Yankee Atomic Electric Co., Westboro, MA). *Trans. Am. Nucl. Soc.;* **23**: 586(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4764 Instrumented pool: a possible way to increase storage capacity.** Gozani, T. (Science Applications, Inc., La Jolla, CA). *Trans. Am. Nucl. Soc.;* **23**: 587-588(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4765 Radiation streaming and reactor cavity shield design.** Willoughby, N.B. (Bechtel Power Corp., Gaithersburg, MD). *Trans. Am. Nucl. Soc.;* **23**: 617(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4766 Code designed to aid teaching LWR thermal analysis.** Robinson, G.E. (Pennsylvania State Univ., University Park); Blakeslee, J.A. *Trans. Am. Nucl. Soc.;* **23**: 73-74(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4767 Utility experience and planning in regard to pipe cracks in BWRs.** Rossin, A.D. (Commonwealth Edison Co., Chicago); Webb, W.; Lapides, M.E. *Trans. Am. Nucl. Soc.;* **23**: 139-140(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4768 Steam generator tube performance in water-cooled reactors.** Hare, M.G. (Chalk River Nuclear Labs., Ont.). *Trans. Am. Nucl. Soc.;* **23**: 140-142(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4769 Behavior of fission gas in LWR fuel during steady-state operating conditions.** Rest, J. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.;* **23**: 171-172(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4770 Multidimensional LWR benchmark problem.** Wagner, M.R. (Kraftwerk Union AG, Erlangen, Ger.); Finnermann, H.; Lee, R.R.; Meneley, D.A.; Micheelsen, B.; Misfeldt, I.; Vondy, D.R.; Werner, W. *Trans. Am. Nucl. Soc.;* **23**: 211-212(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4771 BWR rod bundle benchmark problem.** Zolotar, B.A.; Rahn, F.J. (Electrical Power Research Inst., Palo Alto, CA). *Trans. Am. Nucl. Soc.;* **23**: 214-215(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4772 Two- and three-dimensional BWR kinetics benchmark problem.** Werner, W. (Technische Univ., Garching, Ger.); Finnemann, H.; Langenbuch, S. *Trans. Am. Nucl. Soc.;* **23**: 215-217(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4773 EPRI plutonium recycle program.** Zolotar, B.A.; Roberts, T.A. (Electric Power Research Inst., Palo Alto, CA). *Trans. Am. Nucl. Soc.;* **23**: 238-239(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4774 Methodology for determining economic strategies for plutonium recycle in a system of light-water reactors.** Leaver, D.E. (Stanford Univ., CA); Matzie, R.A.; Connolly, T.J. *Trans. Am. Nucl. Soc.;* **23**: 241-242(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4775 Incremental fuel cycle costs for nuclear power plants.** Antonopoulos, P.T. (Yankee Atomic Electric Co., Westboro, MA); Turnage, J.C.; Forbes, I.A. *Trans. Am. Nucl. Soc.;* **23**: 249-252(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4776 EPRI light-water reactor fuel rod performance program.** Roberts, J.T.A.; Gelhaus, F.E.; Zebroski, E.L. (Electric Power Research Inst., Palo Alto, CA). *Trans. Am. Nucl. Soc.;* **23**: 254-255(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4777 Utility experience in LWR fuel performance.** Pitek, M.T. (Northeast Utilities Service Co., Hartford). *Trans. Am. Nucl. Soc.;* **23**: 255(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4778 Energy analysis of the light-water reactor fuel cycle.** Murty, V.; Freim, J.; Gilliland, M. (Univ. of Oklahoma, Norman). *Trans. Am. Nucl. Soc.;* **23**: 271-272(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## POWER REACTORS, NON-BREEDING, LIGHT-WATER MODERATED, NON-BOILING WATER COOLED

*REFER ALSO TO CITATION(S) 4761, 4762, 4764, 4765, 4766, 4768, 4769, 4770, 4773, 4774, 4775, 4776, 4777, 4778, 4870, 4929, 4932, 5080, 5082, 5086, 5101, 5102, 5104, 5113, 5118, 5119, 5120, 5121, 5133, 5142, 5146, 5148, 5150, 5151, 5152, 5153*

**4779** (CENPD—207) **C-E critical heat flux. Critical heat flux correlation for C-E fuel assemblies with standard spacer grids. Part 2. Nonuniform axial power distribution.** (Combustion Engineering, Inc., Windsor, Conn. (USA)). Jun 1976. 91p. Combustion Engineering, Inc., Windsor, CT.

Results are presented for Critical Heat Flux (CHF) tests with nonuniform axial power rod bundles representative of the Combustion Engineering (C-E) 14 x 14 and 16 x 16 fuel assemblies with C-E standard spacer grids. Data are presented for four 12.5 ft., 5 x 5 array rod bundles with different nonuniform axial power shapes. Those data and other data available in the literature for nonuniform axial power rod bundles with simple grids are compared to CHF predictions made using the TORC subchannel analysis code and the CE-1 uniform axial power CHF correlation modified by the F-factor for nonuniform axial power shapes. It is shown that those results support the minimum DNBR of 1.13 proposed previously for design thermal margin calculations using that correlation for C-E fuel assemblies with C-E standard grids. Results are also presented which show the effect on CHF in C-E fuel assemblies of local perturbations in the axial flux shape. CHF data are presented for two nonuniform axial power rod bundles which were similar except that one test bundle had a heat flux spike (23 percent increase for 4 inches) at the CHF location. It is shown that there is no adverse effect on bundle power at CHF due to that flux spike. It is concluded that CHF margin calculations for C-E fuel assemblies need not include any allowance for the effects of local heat flux perturbations less severe than that tested.

**4780** (NUREG—0103) **Standard technical specifications for Babcock and Wilcox pressurized water reactors.** (Nuclear Regulatory Commission, Washington, D.C. (USA). Office of Nuclear Reactor Regulation). Aug 1976. vp. NTIS.

**4781** (ORNL/NUREG/TM—45) **Zircaloy fuel cladding collapse test plan.** Hobson, D.O. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 52p. Dep. NTIS $4.50.

This test plan outlines the experimental philosophy and procedures for investigating the deformation behavior of Zircaloy fuel cladding under normal and near-normal reactor operating conditions. Such conditions impose compressive hoop and axial stresses on the cladding at temperatures that encompass the time-dependent or creep-strain regime. The purpose of the outlined study is to understand the deformation behavior of cladding under in- and out-of-reactor conditions so that mechanical properties correlations may be developed.

**4782 Fuel assembly for nuclear reactor.** Anthony, A.J.; Hutchinson, J.J.; Klumb, R.H. (to Combustion Engineering, Inc., New York (USA)). French Patent 2,237,276/A/. 2 Jul 1973. 18p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 3 Jul 1972, USA.

The present invention relates to a fuel assembly for nuclear reactors. Such an assembly comprises resilient devices which are partly compressed so as to react downwards against the lower structure of the core support and upwardly against the lower connections of the assembly in order to repel the latter against the core alignment upper structure and to prevent it from being shifted by the hydraulic forces exerted by the circulation of the cooling fluid in the core. This can be applied to heterogeneous nuclear reactors.

**4783** (ERDA-tr—125, pp 106-118) **Investigation of the absolute fluxes and spectra of fast neutrons striking the reactor vessel in the second unit of the Novo-Voronezhskaya AES.** Barinov, A.L.; Vikin, V.A.; Glushchenko, A.I.; Egorov, Yu.A.; Kovalenko, V.V.; Luk'yanov, M.A.; Orlov, Yu.V.; Razumovskii, M.V.; Tsofin, V.I. 1974. Translated from pp 83-93 of Voprosy fiziki zashchity reaktorov, vypusk 6, Atomizdat, Moscow, 1974.

In Questions on the physics of reactor shielding. Volume 6.

Threshold detectors were used to measure the neutron spectra and flux striking the pressure vessel in the Nova Voronezh-2 Reactor.

**4784 Method and installation for reducing radioactive emissions in a nuclear power station.** Shen, T.K.; Coombe, J.R. (to Westinghouse Electric Corp., Pittsburgh, Pa. (USA)). French Patent 2,237,279/A/. 11 Jul 1974. 14p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 11 Jul 1973, USA.

The invention relates to an installation for reducing radioactive emissions in a nuclear power station. The radioactive emissions resulting from leakages between the primary and secondary liquids in a steam-generator of a pressurized-water nuclear power station are reduced by placing a demineralizer in the exhaust of the draining tank and also by sending the draining tank steam towards the condenser. In case of major failures leading to the power station stoppage, an auxiliary turbine is used, the latter being designed for being actuated by the steam derived from the main steam conduit. The auxiliary turbine drives the pumps for pumping the cooling-water intended for the condenser. The steam driving the auxiliary turbine is exhausted towards the condenser, too. Condensed water is returned to the steam generator and is evacuated through the draining tank.

**4785 Emergency device for cooling a nuclear reactor core.** Desmarchais, W.E.; Katz, L.R.; Silverblatt, B.L. (to Westinghouse Electric Corp., Pittsburgh, Pa. (USA)). French Patent 2,239,738/A/. 30 Jul 1974. 17p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 31 Jul 1973, USA.

The emergency cooling system for a nuclear-reactor comprises a pressurized enclosure tightly sealed by an obturating head forming a pressure chamber, a reactor-core in the enclosure, an inlet and an outlet for allowing the coolant to flow, characterized in that it comprises an accumulator containing a pressurized neutron-absorbent connected to the obturating head for providing the pressure-chamber with an emergency-coolant when the coolant pressure within the reactor falls below the pressure within the accumulator, and means in communication with the pressure-chamber and the core for introducing the emergency coolant into the latter.

**4786 Water chemistry and materials corrosion in coolant chemistry.** Weldon, B.A. (International Nickel Ltd., Birmingham (UK)). pp 184-185 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

Short communication.

**4787 Efficiency of serial 440 MW units of nuclear power plants with water-cooled power reactors WWER-440.** Konovalov, G.M.; Kirsh, A.K.; Kanaev, V.D.; Pomerantsev, P.I. *Teploenergetika (Moscow);* No. 9, 52-56(Sep 1975). (In Russian).

Judging by the results of tests of three serially produced 440 MW units, the efficiency of a unit as a whole and of turbine sets K-220-44 is determined. The considerable effect of condenser cooling water supply systems on maximum capacity and efficiency is shown. Based on generalizations, a conclusion is drawn about the possibilities for 440 MW units to attain their efficiency objectives.

**4788 Some general aspects of repetition testing of the material of the primary circuit of nuclear power plants with pressurized water reactors. II.** Bergemann, W.; Roehnsch, W.; Schimmel, W. (Staat Amt fuer At and Strahlenschutz der DDR; Berlin, E Ger). *Energietechnik;* **25**: No. 10, 455-458(Oct 1975). (In German).

The necessity of repetition testing and the importance of developing effective test procedures are discussed. Emphasis is on supplementing 'conventional' test procedures by developing modern telemetering and remote control techniques. It is shown that staggering of test intervals for monitoring the growth of errors can be effected by geometric methods. The discussion could serve for setting up test guidelines. 34 refs.

**4789 SNUPPS nuclear steam supply system.** King, B. (SNUPPS Projects, Westinghouse Electric (USA)). *Nucl. Eng. Int.;* **20**: No. 236, 938-941(Nov 1975).

The design of the SNUPPS Nuclear Steam Supply System (NSSS) is similar to that for units such as Zion 1 and 2, the principal difference being the incorporation of preheat steam generators for SNUPPS, yielding approximately 280 psi (20 kg/cm$^2$) steam pressure increase over the Zion design. A general description is given, followed by details of the support system for chemical and volume control, residual heat removal, safety injection, waste processing, steam generator blowdown processing system, and fuel handling scheme. The SNUPPS project is unique in the total commitment to standardization of five completely separate units. The major stages of organisation of the project are

described. A colored pull-out drawing of the Standardized Nuclear Unit Power Plant System lists main parameters and other general details.

**4790 SNUPPS: the multiple utility standardisation project.** Petrick, N.A. (Standardized Nuclear Unit Power Plant System (SNUPPS) USA). *Nucl. Eng. Int.;* **20**: No. 236, 935-937(Nov 1975).

SNUPPS is a group of five electric utility companies that is building five standardized nuclear plants on four sites in the Eastern and Mid-Western regions of the United States. The SNUPPS (Standardized Nuclear Unit Power Plant System) Project is unique in that it involves indentical plants on multiple sites for multiple utilities. In the spring of 1972 a policy statement of the then United States Atomic Energy Commission (now the Nuclear Regulatory Commision: NRC) gave encouragement to a greater degree of standardization of nuclear power plants. The objective was to reduce the overall time required to build nuclear plants by decreasing the time needed for licensing, engineering, design and construction. 'Duplication' was one of the means suggested to accomplish this end. The organisation and management of the project is described and the objectives are discussed.

**4791 SNUPPS power block engineering.** Thompson, C.A. (Bechtel Power Corp., San Francisco, Calif. (USA)). *Nucl. Eng. Int.;* **20**: No. 236, 941-946(Nov 1975).

The Standard Power Block is based on a modular concept and consists of the following: turbine building, auxiliary building, fuel building, control building, radwaste building, diesel generators building, and outside storage tanks and transformers. Each power block unit includes a Westinghouse pressurized water reactor and has a thermal power rating of 3425 MW(t). The corresponding General Electric turbine generator net electrical output is 1188 MW(e). This standardization approach results in not only a reduction in the costs of engineering, licensing, procurement, and project planning, but should also result in additional savings by the application of experience gained in the construction of the first unit to the following units and early input of construction data to design.

**4792 SNUPPS power block modelling.** Thompson, C.A.; Clothier, W.A. (Bechtel Power Corp., San Francisco, Calif. (USA)). *Nucl. Eng. Int.;* **20**: No. 236, 947-949(Nov 1975).

A series of models is being built and used as tools in the design of the SNUPPS Standard Power Block. The modelling programme includes both preliminary and final design models, a construction sequence mode, and additional models used to study various features of the design. The design of a standard power block unit has necessitated design definition which is more detailed than that customarily used in the design of nuclear power stations. One innovation is the use of engineering models as a primary design tool in the layout of process piping, preparation of isometric drawings, design of small components which are customarily designed in the field during construction. Development of a standard construction sequence and construction work plan is another innovation.

**4793 Reactor internals production under ideal conditions at Pensacola.** *Nucl. Eng. Int.;* **20**: No. 237, 1008-1011(Dec 1975).

The Westinghouse factory at Pensacola, Florida, which specialises in the production of pressure vessel internal components for PWRs, is described. Its excellent manufacturing and inspection facilities, supported by careful attention to staff training and motivation, are responsible for the extremely high level of quality and continual improvement in productivity.

**4794 Selected operating experiences from Stade Nuclear Power Station.** Cramer, H. (Kernkraftwerk Stade, Ger.). *VGB Kraftwerkstech.;* **55**: No. 12, 773-777(Dec 1975). (In German).

Results presented earlier have shown the Stade Nuclear Power Station to be characterized by high availability and low radioactivity discharge values. More recent results are presented regarding individual components of the power plant. In particular, data are presented concerning the behavior of the fuel elements in the first four cycles, examination of corrosion of the steam generator tubes, and acoustic testing of weld seams.

**4795 Intergranular stress corrosion cracking of nickel alloys in pressurized water.** Weber, J.; Sury, P. (Sulzer Brothers Ltd, Winterhur, Switzerland). *Mater. Performance;* **15**: No. 2, 34-43(Feb 1976).

Failures of Alloy 600 and 800 secondary cycle steam generator tubes in Swiss and German nuclear reactors were attributed to design factors and water chemistry changes after operation times up to 14,000 hours. A change in water treatment also is suspected as contributory in one plant. Examinaton of deposits indicated high caustic concentrations are a main factor in intergranular stress corrosion cracking of up to 20% of tubes in one plant. Laboratory tests on samples from failed tubes pointed to incipient hydrogen embrittlement after long exposure in 300 C water and metallurgical conditions similar to those found in material heat sensitized at higher temperatures. 11 refs.

**4796 Spectral modeling for PWRs.** Casadei, A.L.; Turinski, P.J. (Rensselaer Polytechnic Inst., Troy, NY). *Trans. Am. Nucl. Soc.;* **23**: 576-577(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4797 Two-group nodal core simulator based on TRILUX-style coupling.** Forkner, S.L. (Tennessee Valley Authority, Chattanooga). *Trans. Am. Nucl. Soc.;* **23**: 579(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4798 On-line surveillance of core parameters for a pressurized water reactor.** Zwingelstein, G. (Centre d'Etudes Nucleaires, Grenoble, France); Kerlin, T.W. *Trans. Am. Nucl. Soc.;* **23**: 579-580(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4799 Review of physics analyses of Indian Point Unit No. 2 (PWR) fuel assembly storage racks.** Purohit, S.N.; Canavan, G.; Chao, B.; Lee, M.L. (Consolidated Edison, New York). *Trans. Am. Nucl. Soc.;* **23**: 585-586(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4800 Diffusion theory analyses for spent-fuel storage.** Harris, R.T.; Frentzos, D.S.; Jones, W.R. (Northeast Utilities Service Co., Hartford, CT). *Trans. Am. Nucl. Soc.;* **23**: 587(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4801 Extension of Hansen's method to a nonlinear point dynamics model.** Onega, R.J.; Karcher, K.E. (Virginia Polytechnic Inst. and State Univ., Blacksburg, VA). *Trans. Am. Nucl. Soc.;* **23**: 589-590(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4802 Comparison with experiment of xenon oscillation stability calculations using a two-point kinetics model.** Josephson, J. (Argonne National Lab., IL); Geets, J.M. *Trans. Am. Nucl. Soc.;* **23**: 594-596(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4803 Measurements and calculations of neutron streaming within a PWR primary shield annulus.** Anderson, S.L. (Westinghouse Electric Corp., Pittsburgh); Capo, M.A. *Trans. Am. Nucl. Soc.;* **23**: 617-618(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4804 Use of Monte Carlo with albedos to predict neutron streaming in PWR containment buildings.** Cain, V.R. (Bechtel Power Corp., Gaithersburg, MD). *Trans. Am. Nucl. Soc.;* **23**: 618-619(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4805 Monte Carlo analyses of reactor cavity streaming in a PWR.** Boulettwe, E.T.; Hochhalter, E.E. (Stone and Webster Engineering Corp., Boston, MA). *Trans. Am. Nucl. Soc.;* **23**: 619-620(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4806 Dose rates from streaming neutrons up gap by Monte Carlo.** Kamphouse, J.L.; Burke, V.R. (Gilbert Associates, Inc., Reading, PA). *Trans. Am. Nucl. Soc.;* **23**: 620-621(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4807 In-reactor fuel rod bowing characteristics.** King, R.A.; Mayer, J.T.; Spaziani, J.C. (Babcock and Wilcox Co., Lynchburg, VA). *Trans. Am. Nucl. Soc.;* 23: 150-151(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4808 Boron carbide dilatation model for pressurized water reactor application.** Knight, N.F. Jr. (Virginia Polytechnic Inst. and State Univ., Blacksburg). *Trans. Am. Nucl. Soc.;* 23: 176-177(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4809 Thermal-hydraulic benchmarks.** Esposito, V.J. (Westinghouse Electric Corp., Pittsburgh); Morgan, C.D. *Trans. Am. Nucl. Soc.;* 23: 210(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4810 Babcock and Wilcox on-line computer advancements in calculating uninstrumented assembly powers.** Gabler, W.E.; Fulcher, H.D. (Babcock and Wilcox Co., Lynchburg, VA). *Trans. Am. Nucl. Soc.;* 23: 220-221(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4811 Plutonium recycle in Babcock and Wilcox pressurized water reactors.** Uotinen, V.O.; Hanson, G.E.; Killgore, M.R. (Babcock and Wilcox Co., Lynchburg, VA ). *Trans. Am. Nucl. Soc.;* 23: 239-240(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4812 Plutonium burners for nuclear energy centers.** Hellens, R.L.; Rohr, P.C.; Shapiro, N.L. (Combustion Engineering, Inc., Windsor, CT). *Trans. Am. Nucl. Soc.;* 23: 240-241(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4813 Fuel management optimization with limited separative work availability.** Matzie, R.A. (Combustion Engineering, Inc., Windsor, CT); Leaver, D.E.; Connolly, T.J. *Trans. Am. Nucl. Soc.;* 23: 248-249(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4814 Performance of B and W PWR fuel.** Mayer, J.T.; Montgomery, M.H. (Babcock and Wilcox Co., Lynchburg, VA). *Trans. Am. Nucl. Soc.;* 23: 255-256(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4815 C-E/KWU operating experience with LWR fuel.** Smerd, P.G. (Combustion Engineering Inc., Windsor, CT); Stehle, H. *Trans. Am. Nucl. Soc.;* 23: 256-257(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4816 High burnup fuel performance in PWRs.** Jordan, K.R.; Cerni, S.; Boman, L.H. (Westinghouse Electric Corp., Pittsburgh). *Trans. Am. Nucl. Soc.;* 23: 258(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4817 Survey of thorium fuel cycles in PWRs.** Hellens, R.L. (Combustion Engineering, Inc., Windsor, CT); Matzie, R.A.; Rec, J.R.; Sehgal, B.R. *Trans. Am. Nucl. Soc.;* 23: 272-273(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## POWER REACTORS, NON-BREEDING, GRAPHITE MODERATED

*REFER ALSO TO CITATION(S) 4569, 4576, 4948, 4949, 4952, 4953, 4954, 4955, 4956, 4957, 4958, 4959, 4960, 4961, 4964, 4965, 4967, 5105, 5109, 5110, 5144*

**4818 (GA-A—13801(Vol.1)) Process heat engineering design studies for very high temperature reactors.** (General Atomic Co., San Diego, Calif. (USA)). Jul 1976. Contract E(04-3)-167-PRJ-54. vp. Dep. NTIS $10.00.

The results of a study performed for the U.S. Energy Research and Development Administration (ERDA) to investigate process heat applications of a very-high-temperature gas-cooled reactor (VHTR) are reported. This study is a follow-up effort to earlier VHTR application studies performed by General Atomic (GA). Conceptual VHTR plant and component designs are presented in detail for the steam-hydrocarbon reforming process in both integrated and intermediate loop configurations. These designs are evaluated with respect to feasibility, engineering design, economics, safety, reliability, and development considerations. Requirements and criteria are given for VHTR process heat systems, components, reactor fuels, and structural materials. Development objectives are defined for reactor fuels and component structural materials. A general discussion of a VHTR application to the steam-coal gasification process is provided to indicate the direction required for further design and development work, specifically with respect to fuels and materials.

**4819 (GA-A—13836) Economic analysis of U-235 recycle in the HTGR.** Holder, N.D.; Pierce, V.H.; Rothstein, M.P. (General Atomic Co., San Diego, Calif. (USA)). 15 Jul 1976. Contract E(04-3)-0167-PRJ-53. vp. Dep. NTIS $7.75.

A study of various modes of handling spent U-235 fissile particles in either a commercial or demonstration recycle plant has been performed under the Thorium Utilization Program. A detailed engineering study and cost estimate were available for a commercial recycle plant. Using these data as a base, it was possible to project design changes for several modes of U-235 handling and to estimate the resulting effect on the price of HTGR fuel recycle. The results have been combined with preliminary fuel cycle cost comparisons being performed under the HTGR Base Program to determine the most economical scheme for spent fissile fuel recycle. Owing to the cost of replacement U-235, recovering and recycling spent U-235 from initial core and fresh makeup fuel and disposing of the recycled fissile material in particle form as it returns from the reactor is the most cost-effective mode of handling U-235. During the study a possible fuel cycle cost benefit from mixing U-233 spent fissile fuel with the recovered U-235 was identified; this benefit derives from the removal of additional U-236 from the fuel cycle when the combined recycle fissile material is retired. Additional benefits of U-235 recycle include timely high-burnup fuel processing demonstration, uranium resource conservation, and economical Pu-238 source material. A disadvantage of U-235 recycle is the addition of complexity to recycle plant operations due to multiple processes and/or process lines. It is recommended that U-235 recycle be included in the HTGR Recycle Demonstration Facility to assess the risk of multiple processing in a commercial facility.

**4820 (GA-A—13861) Fatigue tests of dowel-socket systems.** Chiang, D.D. (General Atomic Co., San Diego, Calif. (USA)). 15 Jun 1976. Contract E(04-3)-0167-PRJ-51. 57p. Dep. NTIS $4.50.

A test program was conducted to determine the fatigue behavior of LHTGR fuel element dowel/socket systems. Two dowel/socket systems, namely, a four-dowel system and a five-dowel system, were tested to failure under shear loads applied through a fatigue test apparatus to simulate repetitive loading during a seismic event.

**4821 (GA-A—13898) Component and Systems Development Program. Quarterly progress report for the period ending March 31, 1976.** (General Atomic Co., San Diego, Calif. (USA)). 30 Apr 1976. Contract E(04-3)-167. 76p. Dep. NTIS $5.00.

The objectives of the program reported are to provide a data base for the properties of materials used in the noncore construction of important components of the HTGR; to demonstrate the adequacy of the thermal barrier design in two critical areas: (1) fatigue life of attachment fixtures and (2) resiliency of insulation under vibration; and to evaluate HTGR plant availability and reliability.

**4822 (GERHTR—159) Improvement in retention of solid fission products in HTGR fuel particles by ceramic kernel additives.** Foerthmann, R.; Groos, E.; Gruebmeier, H. (Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.)). Aug 1975. 31p. (JUL—1226). Dep. NTIS (US Sales Only) $4.00.

Work performed under United States—German High Temperature Reactor Research Exchange Program.

Increased requirements concerning the retention of long-lived solid fission products in fuel elements for use in advanced High Temperature Gas-cooled Reactors led to the development of coated particles with improved fission product retention which represent an alternative to silicon carbide-coated fuel particles.

Two irradiation experiments have shown that the release of strontium, barium, and caesium from pyrocarbon-coated particles can be reduced by orders of magnitude if the oxide kernel contains alumina-silica additives. It was detected by electron microprobe analysis that the improved retention of the mentioned fission products in the fuel kernel is caused by formation of the stable aluminosilicates $SrAl_2Si_2O_8$, $BaAl_2Si_2O_8$ and $CsAlSi_2O_6$ in the additional alumina-silica phase of the kernel.

**4823** (ORNL/TM—5404) **Irradiation performance of HTGR fuel rods in HFIR experiments HT-26 and -27.** Tiegs, T.N.; Caputo, A.J.; Long, E.L. Jr.; Montgomery, B.H. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 44p. Dep. NTIS $4.00.

Capsules HT-26 and -27 were irradiated in the target region of the High Flux Isotope Reactor. The purpose was to study matrix-particle interaction in High-Temperature Gas-Cooled Reactor fuel rods before and after irradiation. The first objective was to fabricate fuel with a failed fuel fraction less than 0.1 percent. This was accomplished for packed $Al_2O_3$ and in-block carbonization techniques, using annealed Biso-coated fertile particles and either annealed or unannealed Triso-coated fissile particles. The second objective, to irradiate fuel rods and determine the failed fuel fraction (less than 1 percent for acceptable results), was not completely accomplished. In HT-26 the capsule evidently leaked, and the fuel rods suffered attack by steam. In HT-27 the fuel rods only in the high-temperature region suffered attack by zirconium (used as an oxygen getter in the capsule). These problems resulted in failed particles and consequently made it impossible to determine failure fractions due to matrix-particle interaction. Results from the other fuel rods in HT-27 showed that particle failure fractions of less than 1 percent can be obtained from fuel rods carbonized in-tube and irradiated at temperatures up to 900°C fuel surface temperature.

**4824** (ORNL/TM—5436) **Measurement of the relative $^{235}U$ concentration and the absolute $^{235}U$ content of individual HTGR fuel particles.** Knoll, R.W. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 22p. Dep. NTIS $3.50.

The absolute $^{235}U$ content and the relative $^{235}U$ concentration of 77 individual TRISO-coated HTGR fuel particles were measured using delayed-neutron activation analysis. The particles were from batches A611 and A601. The measurements, which were done to determine the variation in kernel $^{235}U$ concentration with kernel diameter, revealed no significant size-dependent variation in the kernel uranium concentration. The absolute measurement technique and its applicability to the construction of assay machine calibration standards are discussed. With the present irradiation facility, the technique was found to be too time consuming to be used to measure the large number of particles needed for a calibration standard individually.

**4825** (ORNL/TM—5436) **Measurement of the relative $^{235}U$ concentration and the absolute $^{235}U$ content of individual HTGR fuel particles.** Knoll, R.W. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 21p. Dep. NTIS $3.50.

The absolute $^{235}U$ content and the relative $^{235}U$ concentration of 77 individual TRISO-coated HTGR fuel particles were measured using delayed-neutron activation analysis. The particles were from batches A611 and A601. The measurements, which were done to determine the variation in kernel $^{235}U$ concentration with kernel diameter, revealed no significant size-dependent variation in the kernel uranium concentration. The absolute measurement technique and its applicability to the construction of assay machine calibration standards are discussed. With the present irradiation facility, the technique was found to be too time consuming to be used to measure the large number of particles needed for a calibration standard individually.

**4826** (ORNL/TM—5501) **HTGR fuel and fuel cycle technology.** Lotts, A.L.; Coobs, J.H. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 48p. Dep. NTIS $4.50.

The status of fuel and fuel cycle technology for high-temperature gas-cooled reactors (HTGRs) is reviewed. The all-ceramic core of the HTGRs permits high temperatures compared with other reactors. Core outlet temperatures of 740°C are now available for the steam cycle. For advanced HTGRs such as are required for direct-cycle power generation and for high-temperature process heat, coolant temperatures as high as 1000°C may be expected. The paper discusses the variations of HTGR fuel designs that meet the performance requirements and the requirements of the isotopes to be used in the fuel cycle. Also discussed are the fuel cycle possibilities, which include the low-enrichment cycle, the Th-$^{233}U$ cycle, and plutonium utilization in either cycle. The status of fuel and fuel cycle development is summarized.

**4827 Mixing of cold and hot co-current air-streams in a packed bed.** Joly, C.; Andrianne, J.; Ginoux, J.J.; Thiry, F. (Von Karman Inst for Fluid Dyn, Rhode Saint Genese, Belgium). *Int. J. Heat Mass Transfer;* 17: No. 8, 803-808(Aug 1974).

A study is presented on how a discontinuity in the temperature distribution of the coolant gas in the inlet section of a packed bed of inert particles is attenuated at the exit section, with emphasis on the design of gas cooled nuclear reactors using coated fuel particles. It is found, both theoretically and experimentally, that a large number of layers of particles is necessary to achieve a sufficient attenuation.

**4828 Concrete nuclear pressure vessel: first of the new generation.** Anon. *Concr. Constr.;* 19: No. 11, 549-552(Nov 1974).

Construction of the pressure vessel at a new type of plant in Colorado is described. To expedite construction, the insulated reactor core barrel was built adjacent to the support ring while the ring was under construction and later moved into place. Cooling coils surround the barrel. Bottom head assembly was built while construction was underway on support ring and later moved by crane onto temporary support steel while 1,400 yards of aggregate for support ring was hand emplaced.

**4829 Thermochemical production of hydrogen from water.** Funk, J.E.; Conger, W.L.; Carty, R.H.; Barker, R.E. (Kentucky Univ., Lexington (USA)). pp vp, Paper 16 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

A review of recent developments in the selection and evaluation of multi-step thermochemical water-splitting cycles is presented. A computerized and thermodynamic and chemical engineering analysis procedure is discussed with calculates, among other things, the thermal efficiency of the process which is defined to be the ratio of the enthalpy change for water decomposition to the total thermal energy required by the process. Changes in the thermodynamic state in each step of the process are also determined. Engineering considerations such as the effect of approach to equilibrium in the chemical reaction steps on the work of separation, and the magnitude of the recycle streams are included. Important practical matters such as thermal regeneration in the product and reactant streams are dealt with in some detail. The effect of reaction temperature on thermal efficiency is described and the use of the analysis procedure is demonstrated by applying it to several processes.

**4830 Thermochemical water-splitting as a method for hydrogen production.** Beghi, G.; Broggi, A.; De Beni, G. (Commission of the European Communities, Ispra (Italy). Joint Nuclear Research Center). pp vp, Paper 17 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

A general explanation of the thermochemical method of water-splitting, and the main characteristics and problems of the chemical cycles are given. Some cycles studied at the JRC Ispra are also described. A computer program for preliminary comparative evaluation of alternative processes is described and the characteristics of the chemical plant and the chemical process/nuclear reactor complex are considered.

**4831 Water splitting processes of the iron-chlorine family.** Cremer, H.; Schubert, J.; Steinborn, G.; Ritterbex, T.; Knoche, K.F. (Lehrstuhl fuer Technische Thermodynamik, RWTH, Aachen (F.R. Germany)). pp vp, Paper 19 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Multi-step processes for thermal water splitting comprise individual chemical reactions which, as far as the iron-chlorine family is concerned, may be generalized: hydrolysis, chlorination, dechlorination, reduction, regeneration of chlorinating agent. These categories comprise series of chemical equations which can be combined to water splitting cycles in different configurations. A systematic estimation of the chemical equations of the five categories is given instead of treating several hundred water-splitting processes of the iron-chlorine family. The individual chemical equations are estimated from published data, by laboratory experiments, and by operating conditions of technical processes.

**4832 Nuclear steelmaking by gasification of lignite.** Wenzel, W. (Institut fuer Eisenhuettenkunde, RWTH, Aachen, (F.R.Germany)); Franke, F.H.; Speich, P. pp vp, Paper 22 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Some systems are discussed for using nuclear energy and brown coal for steelmaking, in order to satisfy middle and long-term energy needs. The basis of such systems is the use of a nuclear reactor as a heat source. The reactor coolant is inert helium gas which is used, after passing through a heat exchanger, to gasify brown coal. One process described for which either fossil fuels or nuclear heat may be used, is the gasification of crude lignite, as mined, with its own moisture content, in horizontal indirectly heated pipes. The reducing gas produced, with differing contents of hydrogen and carbon monoxide is checked before injection into a blast furnace and a direct reduction shaft.

**4833 Aspects of material selection and development for the high-temperature gas-cooled reactor.** Bates, H.G.A.; Betteridge, W.; Graham, L.W. (Organization for Economic Co-Operation and Development, Winfrith (UK). High Temperature Reactor Project). pp 170-176 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

The high-temperature reactor consists essentially of a non-metallic fuel and core system cooled by helium and is currently capable of raising the coolant to a temperature exceeding 1000°C. The thermal energy can be used for steam generation, in a direct-cycle gas-turbine system or for process heat. The metallic materials problems associated with its practical application are mainly concerned with the corrosive effect of trace impurities in the helium and are being studied by the Dragon Project in a major programme of long-time corrosion and creep testing of a wide range of alloys in simulated HTR helium.

**4834 Study of the application of HTGR to a petroleum refinery petrochemical complex.** Anderson, T.D.; Spiewak, I. (Oak Ridge National Lab., Tenn. (USA)). pp vp, Paper 5 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The High-Temperature Gas-Cooled Reactor (HTGR) shows promise as a source of industrial energy for certain applications especially in petroleum refining and petrochemical plants. One limitation to the use of large HTGR's for industrial energy stems from the mismatch in size between nuclear plants and most industrial plants. Even very large refineries could use the output of only one HTGR. The size mismatch, coupled with the need for multiple nuclear units to provide reliability, will limit applications to joint uses of a nuclear power station. One desirable arrangement is for an electric utility to generate both electricity for the grid and thermal energy for local industries. In those places where this arrangement can be implemented, the HTGR would have significant economic advantages over alternative fossil energy systems.

**4835 Convenience of nuclear process heat in the light of energy sources situation.** Antonioli, A. (Rome Univ. (Italy)). pp vp, Paper 6 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The feasibility of using nuclear heat from high temperature reactors is considered for a number of processes and the economics of using nuclear heat are examined. It is concluded that the first generation of such processes should be those with minimum operating temperatures, i.e. fluid bed reduction of iron ore, and steam reforming of natural gas. The question of the need for an intermediate loop between nuclear coolant and process gas should be investigated.

**4836 Extending the temperature range of the HTR.** Balcomb, J.D.; Wagner, P. (Los Alamos Scientific Lab., N.Mex. (USA)). pp vp, Paper 25 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The operating temperature of the high temperature helium-cooled reactor can be increased in a number of ways in order to provide higher temperature nuclear heat for various industrial processes. Modifications are of two types: 1) decrease in the temperature difference between the maximum coated particle fuel temperature and the mean exit gas temperature, and 2) increased maximum coated particle temperature. Gains in the latter category are limited by fission product diffusion into the gas steam and increases greater than 100°K are not forseen. Increases in the former category, however, are readily made and a variety of modifications are proposed as follows: incorporation of coated particles in the fuel matrix; use of a more finely-divided fuel coolant hole geometry to increase heat transfer coefficients and reduce conduction temperature differences; large increases in the fuel matrix graphite thermal conductivity (to about 50 W/m°K) to reduce conduction temperature differences; and modifications to the core distribution, both radially and axially. By such means the exit gas temperature can be increased to the range of 1200°K to 1600°K.

**4837 AVR an existing facility with temperature-level for process application development.** Bialuschewski, H.; Knufer, H.; Ziermann, E. (Arbeitsgemeinschaft Versuchs-Reaktor G.m.b.H., Juelich (F.R. Germany)). pp vp, Paper 47 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The cicumstances under which the mean hot gas temperature of the AVR reactor was raised from 600° to 950°C over a period of 6 yrs. are summarised. The design of the reactor and the reasons for its ability to withstand very high hot gas temperatures are discussed. The effects of the latest temperature rise from 850 to 950°C are examined. The AVR-reactor has an important role in the development of the HTGR reactor for direct cycle power plants with helium turbine and for process heat plants.

**4838 Waste heat of HTR power stations for district heating.** Bonnenberg, H. (Bonnenberg und Drescher Ingenieurgesellschaft m.b.H., Juelich (F.R. Germany)); Schlenker, H.V. pp vp, Paper 37 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The market situation, the applied techniques, and the transport, for district heating in combination with HTR plants are considered. Analysis of the heat market indicates a high demand for heat at temperatures between 100 and 150°C in household and industry. This market for district heating can be supplied by heat generated in HTR plants using two methods: (1) the combined heat and power generation in steam cycle plants by extracting steam from the turbine, and (2) the use of waste heat of a closed gas turbine cycle. The heat generation costs of (2) are negligible. The cost for transportation of heat over the average distance between existing plant sites and consumer regions (25 km) are between 10 and 20% of the total heat price, considering the high heat output of nuclear power stations. Comparing the price of heat gained by use of waste heat in HTR plants with that of conventional methods, considerable advantages are indicated for the combined heat and power generation in HTR plants.

**4839 Some CEA studies on metal behaviour in HTR.** Dixmier, J.; Willermoz, H.; Roche, R. (Commissariat a l'Energie Atomique, (France)). pp vp, Paper 41 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Behaviour of the refractory metals in HTR type helium have been examined at high temperature. Alloys hardened by titanium and aluminium additions show severe intergranular attack at 800°C. At higher temperatures (900°C range) this phenomena is very reduced. Other refractory alloys like Inconel 600, Hastelloy X and Molybdenium alloys are not affected by the temperature increase from 800°C to 900°C. Niobium alloys are strongly hardened in this temperature range. Friction and wear tests are in progress for temperatures between 500 and 1000°C. Indications are given on test apparatus and procedure.

**4840 Graphite and matrix materials for very high temperature reactors.** Everett, M.R. (Organization for Economic Co-Operation and Development, Winfrith (UK). High Temperature Reactor Project); Leushacke, D.F.; Delle, W. pp vp, Paper 46 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Graphites and fuel matrix materials have already been selected and characterised for use in the core structures of existing prismatic and pebble-bed versions of the High Temperature Reactor (HTR). The potential of these materials in accepting an increase of the core helium exit gas temperature from 750°C of present HTR design towards 1000°C for the Very High Temperature Reactor (VHTR) is explored and materials and development aspects discussed.

**4841 Development of very high temperature reactors for process heat supply.** Hosegood, S.B. (Organization for Economic Co-Operation and Development, Winfrith (UK). High Temperature Reactor Project). pp vp, Paper 53 of In High temperature

reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Possible applications of nuclear heat are discussed and the need for a more convenient energy link than heat between the nuclear source and industrial customers is pointed out. Very High Temperature Reactor design is then examined in relation to the special requirements of process heat supply, several design features being tentatively suggested for further study. Finally the need for development of materials and engineering techniques on a broad front is highlighted and co-operative efforts for pursuing this are proposed.

**4842 Development of high temperature heat exchangers made from non-metallic materials.** Hryniszak, W. (Clarke Chapman - John Thompson Ltd., Gateshead (UK)); Moore, R.W.; Osborne, S.J. pp vp, Paper 43 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The demand for higher temperatures for the HTGR type of reactor for process applications will mean the replacement of metals by non-metallic materials. Recuperating or regenerating waste heat also requires further development of heat exchangers to higher efficiency and reduction in physical size, for economic reasons. Some of the advantages of ceramic materials are described. Graphite, silicon carbide and silicon nitride are among these considered suitable for heat exchangers and their engineering properties and fabrication characteristics are discussed. Past and present developments relating to high-temperature ceramic heat exchangers, e.g. in the gas turbine field, are summarised and the effects of ceramic properties on design are considered. It is concluded that both recuperative and regenerative heat exchangers should be intensively investigated and a collaborative program is proposed.

**4843 Metals and alloys for very high temperature reactors.** Huddle, R.A.U. (Organization for Economic Co-Operation and Development, Winfrith (UK). High Temperature Reactor Project). pp vp, Paper 40 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The effect of an HTR helium environment on the structure of metals and alloys at temperatures in the range 850° to 1000°C is discussed. Reference is made to internal oxidation and carburisation as factors responsible for premature failure. The behaviour of the individual alloying elements is treated in some detail and proposals for alloy development are discussed in relation to this behaviour.

**4844 Fundamental issues in the design of HTR for process heat.** Lowthian, C.S. (Nuclear Power Group Ltd., Knutsford (UK)). pp vp, Paper 26 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The design of the reactor system for use with high temperature process heat cycles will rely upon experience gained with earlier HTR designs. Such a reactor must demonstrate assured high availability in order to be commercially preferable to fossil fuels or direct use of electricity. The fundamental basis of the reactor design is examined from this point of view, considering UK experience with gas-cooled reactors. Two conclusions are reached: the first is that safety considerations demand the containment of the reactor and the whole of the primary coolant circuit, and the second that the process heat plant must be located outside this vessel so that conventional access and maintenance facilities can be used.

**4845 HTR particularly designed for process applications.** Malherbe, J.; Tilliette, Z.C. (CEA Centre d'Etudes Nucleaires de Saclay, 91 - Gif-sur-Yvette (France). Div. d'Etude et de Developpement des Reacteurs). pp vp, Paper 28 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Some core and arrangement problems are presented for HTGRs supplying mainly heat at a high temperature level and only a relatively small amount of electricity. Core aspects are considered, particularly the different means of achieving higher temperatures and three methods which could lead to temperatures of 1100°C or more are described. Some basic principles of design are listed and an attempt to adopt them leads to a possible circuit configuration. The effects of this upon the reactor arrangement are illustrated, both in the case of metallic heat exchangers, and for graphite heat exchangers, i.e. for process heat of 900 to 950°C and of >= 1000°C respectively.

**4846 Linear programming fuel management model for the HTGR.** Miller, J.S.; Eckhoff, N.D. (Kansas State Univ., Manhattan (USA). Dept. of Nuclear Engineering). *Ann. Nucl. Energy;* **2**: No. 9;10, 649-656(1975).

Linear programming was used as the optimization technique to minimize the amount of $^{235}U$ used by a model 1160 MW(e) HTGR during three and six burn periods while simultaneously maximizing the production of $^{233}U$. The reactor core was divided into four concentric annular zones; an 'out-in' fuel movement technique was used while the fissile loading of the core was held uniform by adjusting the power peaking constraints. The reactor was linearized by holding the neutron flux constant over each of the burn periods. The model was used to consider three cases: case 1 consisted of three burn periods with no $^{233}U$ recycle, case 2 consisted of six burn periods with no $^{233}U$ recycle, and case 3 consisted of six burn periods with $^{233}U$ recycle allowed at the fourth refuelling event. The results indicate that the amount of $^{233}U$ produced in the first eight years of operation of the 1160 MW(e) HTGR will be sufficient to operate the same reactor with no new $^{235}U$ fuel for 3 yr hence.

**4847 High temperature helium heat exchange loop.** Mori, Y. (Tokyo Inst. of Tech. (Japan)); Ikegami, H.; Nakada, T. pp vp, Paper 49 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Before realizing a nuclear plant complex for iron and steel making, several technical problems remain to be solved in the high temperature heat exchanger and the steam reformer. The loop described was planned by the Iron and Steel Institute of Japan for basic studies on these problems and was turned over to Ishikawajima Harima Heavy Industries for its actual construction on behalf of ISIJ. The loop was designed for carrying out research on heat exchange between helium and steam, hydrogen permeation through super alloys, hydrogen removal using a titanium sponge, and creep carburization performance of super alloys. The primary coolant used was helium having a pressure of approx. 12 kg/cm²g and a measured temperature of approx. 1,100°C at the inlet of the high temperature heat exchanger, i.e., the test section. Steam, hydrogen and carbon monoxide were used as secondary coolants.

**4848 Layout of a high temperature reactor and strategy of introducing nuclear process heat.** Muller, H.W.; Harder, H. (Hochtemperatur-Reaktorbau G.m.b.H., Mannheim (F.R. Germany)). pp vp, Paper 30 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

After showing the necessity of an intensely promoted HTR-development for process heat application a programme is presented which is characterized by a relatively small development effort. Some of the main problems are discussed concerning the layout of a nuclear process heat plant. It is proposed to investigate them in the first phase of the development programme.

**4849 HTR fuel development for advanced application.** Nickel, H.; Balthesen, E. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany)); Graham, L.W.; Hick, H. pp vp, Paper 45 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The advantages of the HTR for nuclear steam supply systems are briefly outlined. Due to its great design flexibility a number of different designs have evolved and the main characteristics of existing experimental prototype and power reactor HTR designs are summarized. The present state of coated particle fuel, particularly with regard to performance, is considered. Some implications of producing higher temperatures are discussed. Finally some of the developments in progress such as minimising the temperature drop between fuel and coolant, and of improving fuel performance by better fission product retention, better chemical stability, and the use of alternative coated materials, are discussed.

**4850 Technical problems of coupling HTRs with chemical and power plants.** Niemeyer, W. (Gesellschaft fuer Hochtemperatur-reaktor-Technik m.b.H., Bensberg (F.R. Germany)); Kunstle, H. pp vp, Paper 31 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The technical problems involved in coupling an HTR with process or power plants are discussed. The provision of an intermediate circuit is investigated and it is shown to be unnecessary for hydrogasification of coal, but unavoidable in the case of steam gasification. The advantages and disadvantages of the intermediate circuit are considered and a short description is given of the heat exchangers. Problems which arise in the plant operation, due to coupling, are briefly examined.

**4851 Evaluation of thermochemical hydrogen and oxygen production from water.** Pangborn, J.B.; Gregory, D.P. (Institute of Gas Technology, ITT Center). pp vp, Paper 15 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

There has been great interest shown recently in producing hydrogen and oxygen from water by sequential operation of multistep chemical reactions. The reactions form a closed cycle in the sense that water is the only input raw material, and hydrogen and oxygen are the only products, while all the intermediate chemical compounds are recycled. For energy input, these cycles can be mated to a nuclear reactor coolant stream, particularly the helium stream of a high-temperature, gas-cooled reactor. At the Institute of Gas Technology, a program to derive, evaluate, and experimentally test such thermochemical water-splitting cycles has been in progress for three years. The results of applying an analysis technique for evaluating water-splitting cycles that are theoretically possible are presented. The thermal energy efficiences for water-splitting by thermochemical and electrochemical routes are discussed. It is concluded on the basis of the nine processes examined that thermochemical processes are superior to electrochemical processes, on the efficiency basis, only when process heat is available in the temperature range of the HTR type of reactor.

**4852 HTGR for coal gasification liquefaction.** Quade, R.N. (General Atomic Co., San Diego, Calif. (USA)); Woebcke, H.N. pp vp, Paper 11 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

A description is given of a solution hydrogasification process for converting bituminous or sub-bituminous coal to a substitute methane gas and a light aromic liquid fuel using heat from an HTGR to generate hydrogen, steam, and power required for the process. The coal solution technique eliminates the requirement for coal pretreatment and yields coal monomers more active than the parent coal. This same basic HTGR-coupled process can be easily modified to produce a clean liquid boiler fuel, hydrogen, or electricity in combination with the basic methane output.

**4853 Experimental facilities for the investigation of hydrogen and tritium permeation problems involved with steam methane reforming by nuclear process heat.** Rohrig, H.D.; Blumensaat, J.; Schaefer, J. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany). Inst. fuer Reaktorentwicklung). pp vp, Paper 50 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Problems of the permeation of hydrogen and tritium through heat exchangers for HTGR reactors and for steam/methane reforming processes in which nuclear heat is used are discussed. An experimental facility is described which was designed to investigate hydrogen permeability through materials of interest at the high temperature involved under process conditions and results of the tests are presented. Plans are also discussed for determination of permeation of tritium produced in the HTR into the chemical products.

**4854 Future developments in fission reactor systems.** Sayers, J.B. (UKAEA Research Group, Harwell. Atomic Energy Research Establishment). pp 21-26 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

The future trend in nuclear reactors will be towards systems providing a combination of high thermal efficiency, good safety characteristics and efficient utilisation of fuel resources, in addition to good overall economics. The high temperature gas cooled reactor (HTR) meets all these requirements. Coolant temperatures of over 800°C are obtainable due to the unique design of the reactor core structure, which is entirely graphitic, the fuel taking the form of small spheres of fissile or fertile ceramic coated with pyrolytic carbon and silicon carbide. Even better utilisation of fuel is obtained in the gas cooled fast reactor, but the very fast high neutron flux levels necessitate the development of alternative fuel concepts.

**4855 Chemical latent heat for transport of nuclear energy over long distances.** Schulten, R.; Von der Decken, C.B.; Kugeler, K.; Barnert, H. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany)). pp vp, Paper 38 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The oil crisis has made clear the necessity to use nuclear energy to an increasing extent for purposes of energy supply and, particularly, for the supply of non-electric energy market. This purpose is served by the energy supply system 'Nuclear Energy over Long Distances', by which nuclear energy is transported in a converted form and transformed into the applicable forms of energy such as hot water or water vapour and electricity. The energy transport involves the transport of the 'latent heat gas', which by chemical reactions will be absorbing or emitting thermal energy. The latent heat gas 'sythesis gas/methane' presents several substantial advantages. The nuclear heat source of the energy supply system 'Nuclear Energy over Long Distances' is the high-temperature reactor.

**4856 Design study of HTGR for process heat application.** Shimokawa, J.; Yasuno, T.; Yasukawa, S.; Miyamoto, Y.; Mitake, S. (Japan Atomic Energy Research Inst., Tokyo). pp vp, Paper 27 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The possible types of a large HTGR (thermal output 3,000 MW, outlet gas temperature 1,000°C) that might be integrated into a plant complex containing the direct reduction-iron making process and electric power generation plants were discussed. Process flow diagrams were made for the plant complex, paying attention to the optimization between the process heat utilization and electric power generation. Design studies were concentrated on the HTGR and its components; this effort ephasises the need to overcome the technical problems of very high temperature.

**4857 High temperature materials for heat exchangers in nuclear process heat plants.** Sowden, R.G.; Antill, J.E.; Livey, D.T.; Wilks, R.S. (UKAEA Research Group, Harwell. Atomic Energy Research Establishment). pp vp, Paper 44 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

A general summary is made of materials which could be useful for heat exchangers in nuclear process heat systems requiring maximum wall temperatures above 1000°C. Among metals, molybdenum-based alloys, nickel-based alloys and reformer tube alloys merit detailed consideration, and non-metals such as silicon carbide, silicon nitride, some oxides and glass ceramics have merits, if brittleness can be tolerated. Uncertainties are enormous, however, without reference to specific design: a plea is made for the materials technologist to link closely with the design engineer once preliminary work on materials fabrication, compatability and general mechanical testing is complete.

**4858 Hydrogasification of brown and hard coal by using heat from gas cooled high temperature nuclear reactors.** Teggers, H. (Rheinische Braunkohlenwerke A.G., Koeln (F.R. Germany)). pp vp, Paper 10 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Development work in the Federal Republic of Germany on the use of heat from high temperature reactors for processes of conversion of solid fuels is discussed. For the conversion of coal with hydrogen to produce methane, the hydrogasification is performed under a pressure of 40 to 100 bar and a temperature of 800 to 900°C. On the basis of experiments in Germany on the behaviour of fluidized beds, and of work in Australia and USA where bench scale and pilot plants for gasification were tested, a pilot plant for hydrogasification in a fluidized bed reactor was designed. A description is given of the plant. Other process schemes for commercial units, which have been developed for the hydrogasification of lignite are also described. These include coupling of nuclear heat by steam reforming of methane and also by preheating of the gasifying agent.

**4859 Economic outlook for HTR reactors in the high temperature process heat market.** Thiriet, L.; Kinsky, T. (Commissariat a l'Energie Atomique). pp vp, Paper 4 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The economic aspects of using nuclear power for process steam are examined and an economic analysis is made of the markets for high temperature steam. It is shown that the circumstances which favour high temperature reactors are the largest possible size in dual purpose plants, high steam/electricity ratio, for small or medium-sized reactors, relatively high fossil fuel costs, and the highest possible load factor. The most promising application in the short and mean term appears to be hydrogen or $H_2 + CO$ production for use in the chemical, petrochemical, and iron and steel industries.

**4860 Liquid lead as heat transfer medium for the use of atomic heat.** Wenzel, W.; Block, F.R.; Vollhardt, F. (RWTH-Aachen (F.R. Germany)). pp vp, Paper 35 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The use in the chemical industry of process heat from HTGR type reactors will require higher temperatures, which create problems concerning heat transfer. Liquid lead was investigated as an intermediate heat carrying medium using graphite heat exchanger. It was concluded that much more research and development would be required particularly on the graphite heat exchanger and on prevention of lead vapor sublimation in cold zones of the reactor. However, successful experiments on gasification of brown coal in a lead bath, and on the use of lead for industrial scale ethylene production, justified further work on the suitability of lead as an intermediate heat transfer medium.

**4861 Significance of the HTR-temperature in the economic use of nuclear heat for coal gasification.** Wiegand, D.; Van Heek, K.H.; Juentgen, H. (Bergbau-Forschung G.m.b.H., Essen (F.R. Germany)). pp vp, Paper 13 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

According to the present state of knowledge an HTR temperature of 950°C is sufficient for steam gasification of hard coal. Higher temperatures lead to an increase of the throughput of coal gasified, decrease of the share of power generation and thereby to a rise of the efficiency of the total plant, which is shown for different products.

**4862** (GERHTR—146) **Droplet model of pyrocarbon deposition from the gas phase.** Linke, J.; Koizlik, K.; Luhleich, H.; Nickel, H. (Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.). Inst. fuer Reaktorwerkstoffe und Heisse Zellen). Jan 1975. Translation of JUL—1156. 104p. Dep. NTIS $5.50.

Work performed under United States—German High Temperature Reactor Research Exchange Program.

Based on extensive earlier work a model has been developed to describe the formation of carbon by pyrolysis of gaseous hydrocarbons. One of the central statements of this model is the assumption of the existence of a quasi liquid carbon phase during deposition process. This model is described and is discussed as are the consequences for the material properties and structural parameters which arise from it. To review the droplet model, statically deposited pyrocarbon is examined by characterization methods suitable to analyze just these structural parameters. The results prove the model conceptions to be realistic.

**4863 Reinforced concrete and prestressed concrete pressure vessels for nuclear power plants.** Schnellenbach, G.; Zerna, W.; Stangenberg, F. (Ruhr Univ., Bochum, Ger.). *VGB Kraftwerkstech.*; **55**: No. 2, 81-88(Feb 1975). (In German).

The construction of pressure vessels from reinforced concrete and prestressed concrete and the new kinds of problems associated with this are described using the SNR (Fast neutron reactor) and HTR (High temperature reactor) nuclear power stations as examples. As the design of these pressure vessels cannot be executed in accordance with existing standards and guidelines because of the special problems, new principles of dimensioning are necessary and these are discussed.

**4864 Fuel elements of the high temperature pebble bed reactor.** Wolf, L.; Ballensiefen, G.; Froehling, W. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany)). *Nucl. Eng. Des.*; **34**: No. 1, 93-108(Oct 1975).

This work is devoted to spherical fuel elements for the high temperature pebble bed reactor, their manufacture and the conditions which they must satisfy for use in a process-heat reactor with an average gas outlet temperature Tsub(G,out) of 950°C. The positive results known from the operation of the AVR with Tsub(G,out)=950°C and from extensive irradiation tests of the THTR-300 element with BISO coated mixed-oxide particles, even beyond the range of design specifications, and possible damage mechanisms are described in detail. They show that a spherical fuel element already exists, for which only a short-term development is needed to produce a coolant temperature of 950°C in a process-heat reactor. Further developments will be characterized by the use of a pebble bed HTR for high conversion rates (c approximately 0.95) or for average gas outlet temperatures of more than 950°C. At higher temperatures the increased demands, mainly with regard to the release of fission products, can be fulfilled through the application of TRISO-coated fuel particles and the doping of the fuel kernels with $Al_2O_3/SiO_2$. The reprocessing program for fuel elements in the Federal Republic of Germany is mentioned briefly.

**4865 Managing the fuel for AGRS.** Nunn, R.M. (Central Electricity Generating Board, Berkeley (UK). Berkeley Nuclear Labs.). *CEGB Res.*; No. 3, 21-30(Dec 1975).

Reactor fuel has to be 'managed' according to a programme designed to minimise capital and operating costs. Each piece of fuel must be made to give up as much energy as possible before it has to be discharged, and the reactor as a whole must maintain criticality with an acceptable internal power distribution throughout its life. The advanced gas-cooled reactors are designed for continuous on-load refuelling. The fuel loses reactivity continuously as the reactor operates and, with an initial fuel charge just sufficient to give criticality, refuelling would normally have to begin within the first few weeks of operation. Many fuel management schemes have been proposed to minimise this potentially wasteful rejection of only partially burned-up fuel. The various possibilities for AGRs are outlined and some of the reasons behind the adoption of the particular strategies to be followed in the current commissioning program are discussed.

**4866 Verification of calculated temperature coefficients of reactivity for $^{233}U$—Th-fueled HTGR lattices.** Newman, D.F.; Gore, B.F. (Battelle Pacific Northwest Labs., Richland, WA). *Trans. Am. Nucl. Soc.*; **23**: 582(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4867 HTGR Neutronics Benchmark Problem.** Steinke, R.G. (General Atomic Co., San Diego, CA); Vondy, D.R.; Gregory, M.V. *Trans. Am. Nucl. Soc.*; **23**: 209-210(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## POWER REACTORS, NON-BREEDING, OTHERWISE MODERATED OR UNMODERATED

*REFER ALSO TO CITATION(S) 5029, 5122, 5123*

**4868 Nuclear energy: current prospects.** Paskievici, W. (Ec Polytech de Montreal). *Ingenieur (Montreal)*; **61**: No. 310, 15-21(Nov-Dec 1975). (In French).

The extent of nuclear penetration into world energy production is indicated, as well as the outlook for future development of nuclear energy. In this connection, the necessity of replacing currently used light water reactors by fast breeder reactors and heavy water reactors which use less uranium is stressed, as well as the urgent need to deal with the extremely complex problems of large-scale reprocessing of enriched fuel. Turning to the situation in Canada, the Canadian nuclear program is described, noting the advantages of the CANDU reactor, which uses heavy water on the moderator and in which the heavy water is physically separated from the heat exchanger. The outlook for further extension of heavy water technology in Canada is assessed, as well as the use of fuels other than natural uranium. It is pointed out that the introduction of fast breeder reactors will produce a savings in uranium only if the breeders are operated jointly with heavy water reactors.

**4869 Radioactivity in nuclear reactor heat transport systems.** Suggitt, J.W. (Ontario Hydro, Toronto). *Ont. Hydro Res. Q.*; **26**: No. 3, 1-2(1974).

**4870 Nuclear reactor pressure circuits.** Cowan, A. (UKAEA Reactor Group, Risley). pp 33-38 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

When part of a pressure circuit is subjected to neutron irradiation the normal requirements to ensure long term pressure in-

tegrity are applied even more rigorously. Neutron irradiation may affect corrosion behaviour, creep deformation and fracture toughness and, additionally, metal radioactivity makes difficult the periodic inspection applied to conventional pressure cicuits and makes in-service repairs difficult or even impossible. Acceptable safety is achieved only if it can be demonstrated that the risk of circuit rupture has an extremely low probability. The engineering demands made on materials are illustrated by reviewing the properties required of Zircaloy-2 pressure tubes, several hundred of which form the in-core pressure containment of the Steam Generating Heavy Water Reactor, and those required of the ferritic steel pressure vessel which forms the primary pressure containment of the pressurised water reactor.

**4871 Britain's steam-generating heavy-water reactor.** Dent, K.H. (UKAEA Reactor Group, Risley); Smith, D.R. *Electron. Power;* **21**: No. 21-22, 1190-1192(11 Dec 1975).

The basic design features of the British-developed steam-generating heavy-water reactor are listed. Operational performance results obtained on the demonstration plant built at Winfrith are discussed. Other pressure-tube reactors built in many countries are briefly described and compared to the British SGHWR. Several aspects of the British commercial plants, which are now being designed, are discussed.

**4872 Britain's steam-generating heavy-water reactor.** Dent, K.H.; Smith, D.R. *Electron. Power;* **21**: No. 21-22, 1190-1192(11 Dec 1975).

In February 1975, The British Government gave consent for the construction of two new nuclear power stations: a 4-unit plant at Sizewell, Suffolk, and a 2-unit plant at Torness in East Lothian. These stations will be the first to use the British-developed steam-generating heavy-water reactor. It is expected that the power plant will be based on the already developed 3000 rpm 660 Mw alternator; after allowing for the plant auxiliaries load, the net unit output will be around 600 MW. The turbine will be a saturated-steam machine with h.p. and l.p. cylinders, moisture separators and probably three double-flow l.p. cylinders. The feed train will consist of the normal extraction pumps, polishing plant, l.p. feed heaters, deaerator, feed pumps and h.p. feedheaters. The turbine stop valve will receive saturated steam at about 62 bar. Because the steam fed to the turbine is generated directly in the reactor channels it is slightly radioactive. The activity comes mainly from the nitrogen 16 (formed by transmutation of oxygen as the water circulates through the reactor core) with its characteristic hard gamma radiation but short 7 s half life. Some additional activity comes, however, from activated corrosion products carried over from the reactor circuit.

**4873 Measurement of fission rate ratios and determination of bucklings of $PuO_2$—$UO_2$ lattices.** Fukumura, N; Iijima, K.; Nishi, A.; Shiba, K.; Kowata, Y. (Power Reactor and Nuclear Fuel Development Corp., Ibaraki, Japan). *Trans. Am. Nucl. Soc.;* **23**: 576(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4874 Simulation of hydrogenous absorbers in heavy-water lattices.** Mohindra, V.K.; Dastur, A.R. (Atomic Energy of Canada Ltd., Mississauga, Ont.). *Trans. Am. Nucl. Soc.;* **23**: 577-579(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4875 Xenon-induced power oscillations in CANDU.** Akhtar, P.; Trojan, O.A. (Atomic Energy of Canada Ltd., Mississauga, Ont.). *Trans. Am. Nucl. Soc.;* **23**: 596(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4876 Specific design features of FUGEN.** Sawai, S. (Power Reactor and Nuclear Fuel Development Corp., Ibaraki, Japan). *Trans. Am. Nucl. Soc.;* **23**: 61(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4877 Design criteria and analysis for a Cirene reactor core.** Bonalumi, R.; Broggiato, A.; Casagrande, I.; Vadacca, V. (ENEL, Rome). *Trans. Am. Nucl. Soc.;* **23**: 61-62(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4878 Spent-fuel management in the CANDU fuel cycle.** Barnes, R.W. (Ontario Hydro, Toronto); Mayman, S.A. *Trans. Am. Nucl. Soc.;* **23**: 65-66(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4879 Environmentally influenced failure of $UO_2$—Zircaloy fuel.** Wood, J.C. (Chalk River Nuclear Labs., Ont.). *Trans. Am. Nucl. Soc.;* **23**: 157-158(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4880 $D_2O$ reactor kinetics benchmark problem.** McDonnell, N. (Chalk River Nuclear Labs., Ont.); Dodds, H.L. *Trans. Am. Nucl. Soc.;* **23**: 217-218(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4881 Use of plutonium in CANDU reactors.** Duret, M.F. (Chalk River Nuclear Labs., Ont.). *Trans. Am. Nucl. Soc.;* **23**: 238(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## POWER REACTORS, BREEDING

*REFER ALSO TO CITATION(S) 4854, 4863, 4868, 5021, 5023, 5059, 5061, 5062, 5075, 5081, 5083, 5084, 5085, 5087, 5088, 5089, 5090, 5092, 5093, 5094, 5099, 5103, 5107, 5108, 5134, 5135, 5143, 5853*

**4882 (AMCO—76-1(Vol.1)) LMFBR large valve development program. Development of the rotating offset-ball isolation valve for liquid metal service. Volume I (sections 1 through 4).** (Aerojet Mfg. Co., Fullerton, Calif. (USA)). Jun 1976. Contract E(04-3)-1035. 168p. AT.

The first volume is presented of a two-volume report describing work by Aerojet Manufacturing Company on the development of an offset pivot ball valve design for application as an isolation valve in the intermediate heat transport system of an LMFBR. (DG)

**4883 (AMCO—76-1(Vol.2)) LMFBR large valve development program. Development of the rotating offset-ball isolation valve for liquid metal service. Volume II (sections 5 through 10).** (Aerojet Mfg. Co., Fullerton, Calif. (USA)). Jun 1976. Contract E(04-3)-1035. 209p. AT.

The second volume is presented of a two-volume report describing work by Aerojet Manufacturing Company on the development of an offset pivot ball valve design for application as an isolation valve in the intermediate heat transport system of an LMFBR. (DG)

**4884 (ANL-CT—76-33) Assumed mode approach to fast reactor core seismic analysis.** Moran, T.J. (Argonne National Lab., Ill. (USA)). Jun 1976. Contract W-31-109-eng-38. 45p. Dep. NTIS $4.00.

The need for a time history approach, rather than a response spectrum approach, to the seismic analysis of fast breeder reactor core structures is described. The use of a Rayleigh-Ritz/Assumed Mode formalism for developing mathematical models of reactor cores is presented. Various factors including structural nonlinearity, fluid inertia, and impact which necessitate abandonment of response spectrum methods are discussed. The use of the assumed mode formalism is described in some detail as it applies to reactor core seismic analysis. To illustrate the use of this formal approach to mathematical modeling, a sample reactor problem with increasing complexities of modeling is presented. Finally, several problem areas—fluid inertia, fluid damping, coulomb friction, impact, and modal choice—are discussed with emphasis on research needs for use in fast reactor seismic analysis.

**4885 (CONF-760503—15) Carbon and nitrogen transport in sodium systems.** Schrock, S.L.; Shiels, S.A.; Bagnall, C. (Westinghouse Electric Corp., Madison, Pa. (USA). Advanced Reactors Div.). 1976. Contract E(11-1)-3045. 37p. Dep. NTIS $4.00.

From International conference on liquified metal technology in energy production; Champion, Pennsylvania, United States of America (USA) (3 May 1976).

Materials for the liquid metal cooled fast breeder reactor will be exposed to high temperature sodium for time periods up to 30 years. One consequence of this exposure will be changes in the interstitial element concentrations of the alloys and concomitant alterations in their mechanical behavior characteristics. Several ongoing technology programs have as their objective a quantitative definition of the rate and extent of this interstitial movement. The paper summarizes the status of these programs and reports in detail on the results of a recently completed, USERDA funded program at the Advanced Reactors Division of Westinghouse. These results, while substantiating earlier reported trends on interstitial movement, indicate the problem is not as severe as initially estimated. Moreover, the present wastage allowance for most reactor components contains sufficient conservatism to compensate for changes in mechanical strength resulting from this change in interstitial concentration.

**4886** (COO—2245-30) **Coolant mixing in LMFBR rod bundles and outlet plenum mixing transients. Progress report, March 1, 1976—May 31, 1976.** Todreas, N.E.; Golay, M.W.; Wolf, L. (Massachusetts Inst. of Tech., Cambridge (USA). Dept. of Nuclear Engineering). 1976. Contract E(11-1)-2245-TAS-1-4. 126p. Dep. NTIS $6.00.

Progress is reported for the following tasks: bundle geometry studies; subchannel geometry studies; outlet plenum flow mixing studies; and the theoretical determination of local temperature fields in rod bundles.

**4887** (COO—2250-22) **MIT LMFBR blanket research project. Quarterly progress report, April 1, 1976—June 30, 1976.** Driscoll, M.J. (Massachusetts Inst. of Tech., Cambridge (USA). Dept. of Nuclear Engineering). 1976. Contract E(11-1)-2250. 24p. Dep. NTIS $3.50.

Analytical and experimental work on the performance of LMFBR breeding blankets is reported.

**4888** (COO—2426-50) **System design of carbide fuel program. Annual technical progress report, GFY 1975.** (Combustion Engineering, Inc., Windsor, Conn. (USA)). Dec 1975. Contract E(11-1)-2426. 75p. (CEND—374). AT.

The prime objective of the System Design of Carbide Fuel Program is to study the benefits of introducing carbide fuel subassemblies into Liquid Metal Fast Breeder Reactors designed for operation with oxide fuel subassemblies. Associated with this overall objective are the parallel objectives of identifying the important characteristics of near term prototype commercial carbide fueled LMFBR designs and the comparison of such designs with designs of oxide fueled LMFBR's. Investigations also include studies of testing of carbide fuel subassemblies in the Fast Flux Test Facility (FFTF) as well as the Clinch River Breeder Reactor (CRBR). The activities conducted during GFY-75 had three main elements. They were: (1) FFTF studies involving the testing of carbide proof test subassemblies in the FTR, (2) CRBR studies dealing with a preliminary assessment of using carbide fueled subassemblies in CRBR, and (3) commercial LMFBR design studies. A summary of activities completed during GPY 75 under these major program elements is presented.

**4889** (HEDL-TC—260-6(Vol.2)) **LMFBR reference fuel development program. Volume 2. Quarterly newsletter, April, May, June 1975.** Hanson, J.E.; Cox, C.M. (comp.). (Hanford Engineering Development Lab., Richland, Wash. (USA)). 1975. Contract E(45-1)-2170. 147p. AT.

Progress in research and development is summarized for the following: fuel pin steady state performance limits; fuel performance analysis and prediction; FFTF fuel evaluation; and LMFBR Fuel-Cladding Information center.

**4890** (HEDL-TME—76-25) **Sodium technology technical progress report, January, February, March 1976.** Atwood, J.M. (Hanford Engineering Development Lab., Richland, Wash. (USA)). Jun 1976. Contract E(45-1)-2170. 96p. AT.

Progress in LMFBR-related sodium technology studies is reported in the areas of radioactivity control, sodium systems development, sodium systems engineering, sodium systems analysis, and the hydraulics and mechanics program. (DG)

**4891** (LMEC—76-1) **Liquid Metal Engineering Center (LMEC) annual technical progress report, January—December 1975.** (Liquid Metal Engineering Center, Canoga Park, Calif. (USA)). 30 Apr 1976. Contract E(04-3)-700. vp. AT.

Information is presented on the development and testing of LMFBR components and systems, including: FFTF HTS/DHX prototype module testing; FFTF prototype pump testing; cold trap testing; FFTF secondary isolation valve testing; electrical resistance heater tests; pressure transducer development and test; proximity sensor testing; sodium-to-gas leak detection tests; solid-state relay testing; cold trap refurbishment; testing for caustic stress corrosion cracking; thermal hydraulic tests of SCTI mixing tees; friction and wear tests in sodium; SPTF thermal insulation test; and Thermal Transient Facility construction.

**4892** (ORNL—5204) **Nondestructive testing development program quarterly progress report for period ending June 30, 1976.** Hill, M.R. (comp.). (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 71p. AT.

Nondestructive testing (NDT) research for LMFBR components is reported. Included are NDT techniques and equipment for inspection and monitoring of steam generator tubes and welded joints, sodium rupture discs, and DNB test sections. NDT methods discussed include radiography, ultrasonics, and eddy currents.

**4893** (ORNL/TM—4210) **MRPP: multiregion processing plant code.** Kee, C.W.; McNeese, L.E. (Oak Ridge National Lab., Tenn. (USA)). Sep 1976. Contract W-7405-eng-26. 66p. Dep. NTIS $4.50.

The report describes the machine solution of a large number (approximately 52,000) of simultaneous linear algebraic equations in which the unknowns are the concentrations of nuclides in the fuel salt of a fluid-fueled reactor (MSBR) having a continuous fuel processing plant. Most of the equations define concentrations at various points in the processing plant. The code allows as input a generalized description of a processing plant flowsheet; it also performs the iterative adjustment of flowsheet parameters for determination of concentrations throughout the flowsheet, and the associated effect of the specified processing mode on the overall reactor operation.

**4894** (ORNL/TM—5355) **Detection of sodium boiling in the fuel failure mockup facility.** Sides, W.H. Jr.; Leavell, W.H.; Saxe, R.F. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 47p. AT.

Tests were performed in the Fuel Failure Mockup (FFM) Facility at ORNL to determine (1) whether sodium boiling in the FFM could be detected acoustically, (2) whether the boiling site could be located, and (3) whether noncondensable gas entrained in the sodium coolant would affect the sensitivity of the detection system. The results indicate that sodium boiling can be detected acoustically. The site of boiling could not be located by measurement of the acoustic pulse arrival time at the sensors. Entrained noncondensable gas in the sodium coolant at void fractions greater than 0.4 percent attenuated the acoustic signals sufficiently that boiling was not detected. At a void fraction of 0.1 percent, indications of boiling were seen on the two acoustic detectors closest to the boiling site.

**4895** (WARD-HT—3045-18) **Analysis of cracks in piping elbows.** Wilson, W.K. (Westinghouse Electric Corp., Madison, Pa. (USA). Advanced Reactors Div.). Jul 1976. Contract E(11-1)-3045. 67p. AT.

A review of the analytical information presently available to support a leak-before-break line of defense of the integrity of piping subjected to cyclic loading was performed. Special emphasis was placed upon the inlet downcomer elbow of a LMFBR plant. Using available stress intensity factor information for surface cracks and extrapolating where necessary, calculations of the cyclic history of the size and shape of growing surface cracks were carried out for various cyclic loading conditions. Areas where additional analytic work is required to develop a valid leak-before-break argument have been noted and the specific form of work to be carried out has been described.

**4896** (ANL-Trans—1072) **Problems related to the definition of the shielding of a large fast power reactor.** Moreau, J. (CEA Centre d'Etudes Nucleaires de Cadarache, 13 - Saint-Paul-les-Durance (France)). 1972. Translated from pp 103-120 of paper presented at the fourth international conference on reactor shielding, Paris, France, October 9—13, 1972. (CONF-721018—31). 20p. Dep. NTIS $3.50.

From 4. international conference on reactor shielding; Paris, France (9 Oct 1972).

Solutions for the shielding of a 1000 MW(e) power plant in the same technological line as Phenix are given. They have been evaluated with a monodimensional transport code. The choice is based on the comparison of their efficiency towards neutrons and on the consequences of their characteristics on the conception of the reactor tank. A few economical considerations give an idea of the influence of the choice in shielding on the cost of the power plant. At last the problem of the optimization possibilities is approached from the designer's point of view.

**4897** **Regulating assembly for nuclear reactors.** Kuzavkov, N.G.; Pakhomov, V.V.; Prin, I.I.; Shabalin, A.S. French Patent 2,237,277/A/. 14 May 1974. 11p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 14 May 1973, USSR.

The regulating assembly as suggested comprises a sheath fixedly mounted in the reactor active zone with a casing moving within the sheath. In that casing are superimposed two bundles of fuel elements and absorbing elements, respectively. Substantially at the border between these bundles, the casing is provided with ports for deflecting a portion of the cooling agent to which the bundles are exposed towards the free space between the sheath and casing. A throttling device is provided at the level of the absorbing elements for regulating the flow rate of the cooling agent deflected through the ports, in proportion to the casing location with respect to the reactor active zone. This regulating assembly is to be used mainly in fast neutron nuclear reactors.

**4898 Permanent-magnetic sodium flowmeters for nuclear power stations.** Dorff, D.; Hans, R. (Vacuumschmelze, Berlin). *Siemens Rev.*; **42**: No. 1, 15-17(Jan 1975).

Of the three flowmetering systems developed for liquid-metal-cooled breeders, namely the permanent-magnetic, electromagnetic and inductive systems, preference has been given in the Federal Republic of Germany to the permanent-magnetic method. Permanent-magnetic systems are available for nominal pipe diameters of 15 to 600 mm. A description is given of the general metering arrangement, the technical data are tabulated and an account is given of the experience gathered in 12 years of practical operation.

**4899** (EURFNR—1295) **Fuel pin design and control program system MERKUR.** Steinbock, L. (Kernforschungszentrum Karlsruhe (Germany, F.R.). Inst. fuer Material- und Festkoerperforschung). Sep 1975. Translation of KFK—2163. 30p. Dep. NTIS $4.00.

An interactive APL-program system for pin design and specification was developed, which only needs limited activities of the user. All material properties, which are frequently used, are selected by key words from a data bank, i.e., for the clad material "1.4970" and are built into the program. At the time being the program gives an accurate thermal and neutronic and a rough mechanical specification for the pin with prescribed values for the plutonium distribution and stoichiometry distribution. The nuclear specification comprises a one group transport calculation from the clad surface inward. The system contains in addition to the calculational programs some conversational programs, which support the user during input and output and enable the plotting of the generated datas.

**4900** (EURFNR—1296) **Contribution to the analysis of the thermal behavior of fast breeder fuel rods with $UO_2$—$PuO_2$ fuel.** Elebel, H.; Lopez, J.; Jimenez. (Kernforschungszentrum Karlsruhe (Germany, F.R.)). Oct 1975. Translation of KFK—2216. 101p. Dep. NTIS $5.50.

Work performed under United States—Euratom Fast Reactor Exchange Program.

The fuel of Fast Breeder Reactors, which consists of uranium and plutonium dioxide, is mainly characterized by the amount and distribution of void volume and plutonium and the amount of oxygen. Irradiation experiments carried out with this fuel have shown that the initial structure of the fuel pellet is subjected to large changes during operation. These are consequences of the radial and axial temperature gradients within the fuel rod. In several parametric studies undertaken with the computer code system SATURN the influence on the thermal behavior of a fuel pin has been analyzed which is caused by restructuring processes such as pore migration, oxygen and plutonium redistribution due to the radial temperature gradient. The formation of a central hole occurring as result of pore migration as well as the oxygen redistribution in hypostoichiometric fuel lead to a decrease in the temperature profile. Rise of the plutonium concentration in the inner zone of the fuel pellet counterbalances this trend. The influence has been shown which the restructuring processes and the thermal qualities of the fuel, e.g., heat conductivity and thermal expansion exert due to their dependency on the amount of oxygen.

**4901 Nuclear reactors.** Wolff, P.H.W. (to Nuclear Power Co. (Whetstone) Ltd. (UK)). British Patent 1,412,949/B/. 5 Nov 1975. 5p.

Reference is made to liquid metal cooled reactors in which a tank containing molten Na is provided in which the core, and possibly other plant items, are immersed. In such a reactor a sealing membrane or cover must be provided over the pool of liquid coolant in the tank, and above the membrane there is a massive steel roof structure to provide shielding and possibly to support reactor equipment. This structure is kept relatively cool for a number of reasons, such as to preserve its structural integrity, to permit access of personnel to the top of the reactor, etc. The Na in the pool will be at a temperature of about 400°C, and the thermal expansion of a free tank containing the Na will be substantial. It is therefore necessary to adopt designs that can accommodate the dimensional discrepancy between the hot tank and the cold roof. A tight seal must also be provided against the escape of radioactive materials from the reactor and against ingress of fluids that might react with Na. Stresses in all parts also must not exceed acceptable values. Sliding joints cannot be considered but welded connections must be employed. An arrangement is described to meet these requirements.

**4902 Kalkar Nuclear Power Plant: a prototype.** Borsetzky, K.D. (Rhein-Westfael Elektrizitaetswerk, Essen). *VGB Kraftwerkstech.*; **55**: No. 12, 815-824(Dec 1975). (In German).

A description is given of the design of a 300-MW prototype nuclear power plant with a fast sodium-cooled reactor now being built at Kalkar on the Lower Rhine as part of a project of development of a fast breeder reactor. The energy conversion process takes place in three heat transport systems connected in series. The thermal energy generated in the breeder reactor is transported by liquid sodium in the closed primary cooling system via intermediate heat exchangers to liquid sodium in the secondary cooling system. The thermal energy absorbed by the sodium of the secondary cooling system is transported in the steam generators to the feed water of the steam system. The superheated steam thus formed drives the turbogenerator. The steam system is not connected directly to the primary cooling system, because sodium reacts very violently with water and becomes activated in the reactor core. By using a secondary, inactive sodium cooling system, assurance is gained that in the event of a large leak in the steam generators only sodium-water reactions involving inactive secondary sodium can take place.

**4903 Fast reactor progress in the Soviet Union.** Rippon, S. (Nuclear Engineering International, London (UK)). *New Sci.*; **68**: No. 978, 570-572(4 Dec 1975).

The progress of Soviet fast reactor projects, which show a more orderly progression in size and sophistication than the parallel efforts in other countries, is outlined. The first reactor, BR5, went into operation in 1958 with a nominal electrical output of 5 MW(e) and was upgraded in 1972. The first prototype fast reactor power plant, which provides steam for electrical turbines and for a desalination plant, was BN350 at Shevchenko, which started up in 1973. Operation of the plant, including the incident which caused the steam generator damage, is discussed. Radiological protection aspects of the Soviet program, including the question of containment, are considered. The present position of the 600 MW(e) fast reactor commercial power station which is at present under construction is given.

**4904 Analysis of simulated steam entry in the GCFR critical experiments.** Hess, A.L.; Rucker, R.A.; Moore, R.A. (General Atomic Co., San Diego, CA). *Trans. Am. Nucl. Soc.*; **23**: 563(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4905 Reactivity worth of helium gas in a GCFR assembly.** Bucher, R.G.; Groh, E.F. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.*; **23**: 563-564(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4906 Measurements and analyses of neutron leakage effects in the GCFR Phase I critical experiments.** Wade, D.C.; Morman, J.A.; Krack, K.R.; Robinson, W.R.; Bhattacharyya, S.K.; McKnight, R.D. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.*; **23**: 564-565(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4907 Power and reactivity distribution in the Clinch River Breeder Reactor at beginning-of-life (BOL).** Kalimullah; Hummel, H.H. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.*; **23**: 570(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4908 Measurements and calculations of neutron fluxes through a simulation of the CRBR upper axial shielding.** Maerker, R.E.; Muchenthaler, F.J. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.*; **23**: 611-612(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4909 Radiation streaming problems in a 300—MW(e) gas-cooled fast breeder reactor.** Cerbone, R.J.; Rouse, C.A.; Perkins, R.; Nagel, M. (General Atomic Co., San Diego, CA). *Trans. Am. Nucl. Soc.;* **23**: 623-624(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4910 Analysis of the GCFR pin streaming experiment performed at the TSF.** Slater, C.O.; Bartine, D.E. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.;* **23**: 624-625(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4911 Reirradiation of mixed-oxide fuel pins at increased temperatures.** Lawrence, L.A.; Weber, E.T. (Hanford Engineering Development Lab., Richland, WA). *Trans. Am. Nucl. Soc.;* **23**: 143-144(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4912 Cesium relocation in mixed-oxide fuel pins resulting from increased temperature reirradiation.** Lawrence, L.A.; Woodley, R.E.; Weber, E.T. (Hanford Engineering Development Lab., Richland, WA). *Trans. Am. Nucl. Soc.;* **23**: 144-146(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4913 Axial fuel redistribution by vapor or transport in LMFBR fuel rods.** Harbourne, B.L.; McCarthy, W.H. (General Electric Co., Sunnyvale, CA). *Trans. Am. Nucl. Soc.;* **23**: 146-147(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4914 Observed cladding response to LMFBR fuel rod design parameters.** Rosa, J.M.; Hibert, R.F. (General Electric Co., Sunnyvale, CA). *Trans. Am. Nucl. Soc.;* **23**: 147(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4915 Measured internal gas-flow conductance of an operating GCFR fuel rod.** Longest, A.W. (Oak Ridge National Lab., TN); Conlin, J.A.; Campana, R.J. *Trans. Am. Nucl. Soc.;* **23**: 148-149(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4916 Transport and reaction of volatile fission product in gas-cooled fast reactors.** Johnson, C.E.; Johnson, I. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.;* **23**: 149-150(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4917 Observations on the geometry of an irradiated Rapsodie subassembly.** Blanchard, P.; Leclere, J.; Ollier, H. (Centre d'Etudes Nucleaires de Cadarache, St. Paul lez Durance, France). *Trans. Am. Nucl. Soc.;* **RR**: 151-152(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4918 Recent advances in delineation of the mechanism of intergranular attack in stainless steel by fission products.** Aitken, E.A.; Adamson, M.G. (General Electric Co., Sunnyvale, CA). *Trans. Am. Nucl. Soc.;* **23**: 153(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4919 Chemical attack of cladding in mixed-oxide fuel elements.** Johnson, C.E. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.;* **23**: 153-154(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4920 Evolution of cladding attack in LMFBR-type oxide fuel pins.** Weber, J.W.; Gibby, R.L.; Hata, D.C.; Weber, E.T. (Hanford Engineering Development Lab., Richland, WA). *Trans. Am. Nucl. Soc.;* **23**: 154-155(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4921 Analysis of fuel-cladding chemical interaction in mixed-oxide fuel pins.** Weber, J.W.; Dutt, D.S. (Hanford Engineering Development Lab., Richland, WA). *Trans. Am. Nucl. Soc.;* **23**: 155-156(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4922 Fuel-cladding gap-conductance model for LMFBR fuel elements.** Chow, L.S.H.; Billone, M.C. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.;* **23**: 170-171(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4923 Crack healing correlation predicting recovery of fracture strength in LMFBR fuel.** Lovejoy, W.S.; Evans, S.K. (General Electric Co., Sunnyvale, CA). *Trans. Am. Nucl. Soc.;* **23**: 174-176(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4924 Analyzing the role of the LMFBR in the U.S.** Omberg, R.P. (Hanford Engineering Development Lab., Richland, WA). *Trans. Am. Nucl. Soc.;* **23**: 188(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4925 Buckingham's $\pi$-theorem applied to a reactor-physics optimization problem.** Ma, B.M. (Iowa State Univ., Ames). *Trans. Am. Nucl. Soc.;* **23**: 222-223(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4926 Evaluation of LMFBR blanket configurations.** Brown, G.J. (Univ. of Lowell, MA); Driscoll, M.J. *Trans. Am. Nucl. Soc.;* **23**: 273-274(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## POWER REACTORS, AUXILIARY, MOBILE, PACKAGE, AND TRANSPORTABLE

**4927 (AD-A—012148) Thermal hydraulic analysis of MH-1A Core 5. Final report.** Gignilliat, H.C.; Francisco, P.E.; Rotchford, T.M.; DeVault, R.M. (Army Engineer Power Group, Fort Belvoir, Va. (USA). Engineering Div.). 1 May 1974. 79p. (USAENPG-ED—7401). NTIS $4.75.
The thermal hydraulic analysis of Core 5 for the MH-1A Floating Barge Nuclear Power Plant is presented. The primary purpose of this study is to demonstrate that the reactor core is capable of meeting normal steady-state and transient performance requirements without violating the integrity of the fuel-element cladding. The analyses presented define the limits of safe operation for the core in terms of measurable reactor parameters: reactor power, primary system pressure, coolant temperature and flow. The reactor protection system is designed to trip the reactor to protect the core in the event that reactor parameters approach the core design limits. The steady-state thermal analysis shows that the prescribed setpoints with allowance for error assure protection during all normal operations. The analysis of limiting reactor transients caused by operator error or equipment malfunction demonstrates the adequacy of the protection system in assuring that core limits are not exceeded during anticipated transient conditions. (GRA)

**4928 (N—75-24843) Evaluation of refractory-metal-clad uranium nitride and uranium dioxide fuel pins after irradiation for times up to 10,450 hours at 990°C.** Bowles, K.J.; Gluyas, R.E. (National Aeronautics and Space Administration, Cleveland, Ohio (USA). Lewis Research Center). Jun 1975. 64p. (NASA-TN-D—7891; E—7988). NTIS $4.25.
The effects of some materials variables on the irradiation performance of fuel pins for a lithium-cooled space power reactor design concept were examined. The variables studied were UN fuel density, fuel composition, and cladding alloy. All pins were irradiated at about 990°C in a thermal neutron environment to the design fuel burnup. An 85-percent dense UN fuel gave the best

overall results in meeting the operational goals. The T-111 cladding on all specimens was embrittled, possibly by hydrogen in the case of the UN fuel and by uranium and oxygen in the case of the $UO_2$ fuel. Tests with Cb-1Zr cladding indicate potential use of this cladding material. The $UO_2$ fueled specimens met the operational goals of less than 1 percent cladding strain, but other factors make $UO_2$ less attractive than low-density UN for the contemplated space power reactor use. (Auth)

## REGULATION AND LICENSING

**4929 Scope, procedures and schedule for generic environmental impact statement and criteria for interim licensing actions. Mixed oxide fuel.** *Fed. Regist.* (*Wash., D.C.*); **40**: No. 221, 53056-53063(14 Nov 1975).

From Nuclear Regulatory Commission.

This notice sets forth the Commission's determination that the subject of wide-scale use of mixed oxide fuel in the light water power reactor fuel cycle requires a full assessment of safeguards issues before the Commission's decision is made; specifies the procedures and schedule to be followed for completion of the environmental impact statement on wide-scale use of mixed oxide fuel and for the conduct of the associated hearings; and sets forth criteria under which certain licensing actions can proceed in the interim prior to the Commission's decision on the wide-scale use of mixed oxide fuel.

**4930 (NUREG/PRDI—76/9) Power Reactor Docket Information.** (Nuclear Regulatory Commission, Washington, D.C. (USA)). Sep 1976. 51p. TIC $3.50.

Citations and subject indexing to the documentation associated with civilian nuclear power plants are presented. This material is that which is submitted to the U.S. Nuclear Regulatory Commission support of applications for construction and operating licenses. Citations are listed by Docket number in accession number sequence. The Table of Contents is arranged both by Docket number and by nuclear power plant name. (DG)

**4931 (RDT-M—2-4T(4-76)) Alloy steel forgings (ASME SA-336 with additional requirements).** (Energy Research and Development Administration, Washington, D.C. (USA). Div. of Reactor Development and Demonstration). Apr 1976. Contract W-7405-eng-26. 7p. RSO.

The standard presented covers alloy steel forgings for nuclear and associated applications. Specifications are listed under the headings of general requirements, basis of purchase, additional requirements, application supplements, and optional provisions.

**4932 (REG/G—1.117(6-76)) Tornado design classification.** (Nuclear Regulatory Commission, Washington, D.C. (USA). Office of Standards Development). Jun 1976. 3p. NUREG.

This guide describes a method acceptable to the NRC staff for identifying those structures, systems, and components of light-water-cooled reactors that should be designed to withstand the effects of the Design Basis Tornado (see Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants"), including tornado missiles, and remain functional.

**4933 Nuclear power plant lighting.** *J. Illum. Eng. Soc.*; **5**: No. 2, 107-116(Jan 1976).

The Electric Generating Station Subcommittee has been studying and evaluating the lighting needs for nuclear power plants through committee member experience and through committee inspections of various types of facilities. This practice should be used in conjunction with the 'American National Standard Practice for Industrial Lighting' and the IES material listed in the bibliography of that publication. 9 refs.

## ECONOMICS

*REFER ALSO TO CITATION(S) 5188*

**4934 Cost economics of nuclear power plants in the US.** Akhtar, S. M. *J. Inst. Nucl. Eng.*; **15**: No. 5, 144-151(1974).

The cost economics associated with the nuclear power plants is examined with a simplified approach to provide some insight into the complexity of evaluating nuclear fuel costs. Also described are the direct and indirect costs in 1973 dollars (and $/kW magnitude) as they have developed since 1963, and cost trends for the future are predicted.

**4935 Economic and industrial aspects of French nuclear power policy.** Vendryes, Georges (CEA, 75 - Paris (France)). *Rev. Def. Natl.*; **31**: 17-38(Mar 1975). (In French).

This account starts with a general survey of energy needs and resources, so as to situate in this context the development of the fifty nuclear power stations planned for operation in France by 1985. Then the increasing competitivity of nuclear generated electrical power is demonstrated. The article deals with problems involved in the fuel cycle: uranium supplies, enrichment, fuel element fabrication and reprocessing. In this area, as in that concerning the more distant future of fast breeder reactor plants, and thanks to the efforts of the scientists and technicians of the EA and French manufacturers, France occupies a significant place among competitors in the field. With the cooperation of other European countries, this should make it possible for Europe to increase its independence from the current American monopoly, which is of considerable proportions.

**4936 IAEA general conference confident but... Special report from the annual meeting of the IAEA in Vienna, 22-26 September.** *Nucl. Eng. Int.*; **20**: No. 236, 959-960(Nov 1975).

A brief review is given of the 19th Session of the General Conference of the IAEA, held in September in Vienna. A major theme was investment finance, highlighting the conflict between short and long term economics in relation to nuclear power plants. The problem of finance for developing countries was referred to by several delegates and particular reference is made to the presentation of the problems by Dr. Friedmann of the World Bank. Other topics singled out for reference were various aspects of nuclear power expansion in developing countries including the idea of centralised fuel cycle services and also the non-availability, in spite of potential market, for the small nuclear power stations of around 200 MW(e). The joint project of the IAEA and the International Institute for Applied Systems Analaysis on risk assessment and public acceptance of risk is discussed.

**4937 Nuclear power, coal, and energy conservation: with a note on the cost of a nuclear moratorium.** Auer, P.L.; Manne, A.S.; Yu, O.S. (Electric Power Research Inst., Palo Alto, CA). *Trans. Am. Nucl. Soc.*; **23**: 187-188(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4938 Effect of advanced reactor strategies on electrical costs and resource consumption.** Waddell, J.D. (Battelle Columbus Labs., Columbus, OH); O'Hara, F.A.; Willke, T.L. *Trans. Am. Nucl. Soc.*; **23**: 269-271(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

### FUEL CYCLE

*REFER ALSO TO CITATION(S) 4774, 4778, 4819, 5521*

**4939 (CONF-760826—7) Overview of light water reactor fuel cycles.** Leuze, R.E. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-eng-26. 28p. Dep. NTIS $4.00.

From American Chemical Society meeting; San Francisco, California, United States of America (USA) (29 Aug 1976).

A brief overview of the LWR fuel cycle is given, and the status of the LWR fuel cycle in the U.S. is briefly summarized. A broad base including a variety of industrial facilities is necessary to provide fuel for LWR's. However, capital investments for all the facilities combined are only about 15 percent of the capital needed for the reactors themselves. Capability for the front end of the fuel cycle, mining through fuel fabrication, is adequate for the present, but the expanded capacity will be required in 15 to 20 years, and this calls for immediate action because of long lead times. There are no operating facilities for the back-end of the fuel cycle, which includes spent fuel reprocessing, permanent waste storage, and mixed-oxide fuel fabrication. Decisions must be made concerning permanent waste storage concepts and regulations relating to the use and handling of plutonium before such facilities can be provided and put into operation. (LK)

**4940 Optimization of the operation of nuclear power plants.** Ackermann, G.; Hampel, R.; Luetzow, K.; Meyer, K. (Ingenieurhochsch, Zittau, Ger.). *Energietechnik*; **25**: No. 10, 336-450(Oct 1975). (In German).

A model, called DYOP, is described. With the aid of 'dynamic optimization', it allows the determination of optimal feeding of fuel during the lifetime of a nuclear power plant with a pressurized water reactor, when the load requirements vary during the lifetime. Results obtained with the aid of a minicomputer are reported and tabulated. 7 refs.

**4941 Nuclear fuel cycle.** *Nucl. Eng. Int.*; **20**: No. 237, 1015-1020(Dec 1975).

The papers presented at the International Conference on The Nuclear Fuel Cycle, held at Stockholm, 28 to 31 October 1975, are reviewed. The meeting, organised by the U.S. Atomic Industrial Forum, and the Swedish Nuclear Forum, was concerned more particularly with economic, political, social and commercial aspects than with tecnology. The papers discussed were considered under the subject heading of current status, uranium resources, enrichment, and reprocessing.

**4942 Fuel cycle forecasting - there are forecasts and there are forecasts.** Puechl, K.H. *Nucl. Eng. Int.;* **20**: No. 237, 1012-1014(Dec 1975).

The FORECAST-NUCLEAR computer program described recognizes that forecasts are made to answer a variety of questions and, therefore, that no single forecast is universally appropriate. Also, it recognizes that no two individuals will completely agree as to the input data that are appropriate for obtaining an answer to even a single simple question. Accordingly, the program was written from a utilitarian standpoint: it allows working with multiple projections; data inputting is simple to allow game-playing; computation time is short to minimize the cost of 'what if' assessements; and detail is internally carried to allow meaningful analysis.

**4943 Integrated approach to problems in the nuclear fuel cycle.** Miles, W.T.; Roberts, D.J. (Energy Research and Development Administration, Washington, DC). *Trans. Am. Nucl. Soc.;* **23**: 244-245(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4944 Rethinking nuclear fuel management: a perspective.** Hughes, J.A.; Tomonto, J.R. (Florida Power and Light Co., Miami). *Trans. Am. Nucl. Soc.;* **23**: 246(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4945 Equilibrium cycle costs with alternative fuel management strategies.** Lee, R.B.; DeMasi, V.D. (GPU Service Corp., Bethpage, NY). *Trans. Am. Nucl. Soc.;* **23**: 246-248(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4946 Plutonium value analysis.** Hardie, R.W. (Hanford Engineering Development Lab., Richland, WA). *Trans. Am. Nucl. Soc.;* **23**: 252-253(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4947 Analysis of time-dependent inventory levels of fabricated nuclear fuel assemblies.** Kurstedt, H.A. Jr. (Virginia Polytechnic Inst. and State Univ., Blacksburg); Nachlas, J.A.; Lyons, J.R. *Trans. Am. Nucl. Soc.;* **23**: 269(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## PROCESS HEAT REACTORS

*REFER ALSO TO CITATION(S) 4399, 4829, 4830, 4831, 4832, 4834, 4835, 4836, 4841, 4844, 4845, 4847, 4848, 4850, 4851, 4852, 4853, 4856, 4857, 4858, 4859, 4860, 4861, 5026*

**4948 Nuclear heat.** Schulten, R. (Technische Hochschule Aachen (F.R. Germany); Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany)). pp 63-68 of In Wege zur Schliessung der Energieluecke. Rau, J.; Peters, W.; Schubert, E.; Knizia, K.; Krieb, K.H.; Dibelius, G.; Schulten, R.; Opitz, M.; Pichler, H. Dortmund, F.R. Germany; Verkehrs- und Wirtschaftsverl. Borgmann (1974). (In German)

1 fig.

A short survey is given on the possible applications of nuclear heat, especially those in the energy distribution: 1) coal gasification, 2) methane fission, 3) hot water transport and 4) thermal water fission. Furthemore, it is shown how a coupling of these 4 kinds of energy transport is possible in a future energy economy.

**4949 Reduction processes with a high degree of gas utilization and with the aid of nuclear heat.** Block, F.R.; Stolzenberg, G. (RWTH, Aachen (F.R. Germany)). pp vp, Paper 21 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

With fossil fuels becoming rarer and more expensive, nuclear heat can be used to gasify coal with steam or carbon dioxide to produce hydrogen and carbon monoxide and derived hydrocarbons. Particularly, the iron and steelmaking industry has an immense demand for these gases. At present, large quantities are produced either in the blast furnace itself or in suitable gas generators directly coupled to the reduction plant. Because the waste gases are used for heating the gas generator an optimised usage is assured. Nuclear energy can be employed for that part of the operation in which fossil fuels are used to supply heat. New processes are indicated either to avoid the occurrence of waste gases or to utilize them in the production of fresh reduction gas. The requirements of the reduction process and the ways in which the nuclear reactor, the gas generator, and the reduction plant have to be linked to obtain technically feasable complexes are discussed.

**4950 Reforming of methane in tubes with a catalytic active wall.** Fedders, H.; Decken, C.B. Von der (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany)). pp vp, Paper 7 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The heterogeneous steam reforming process in tubes with catalytic active inner surface is studied. The purpose of this ivestigation is to find a method of predicting the reaction rate of the catalytic conversion of methane by steam. The dependency of the reaction rate upon the temperature, pressure, gas composition, Reynolds number, geometrical sizes of tubes and catalytic behaviour of the catalytic active inner wall of these tubes has been examined. It was found that the reaction rate mainly depends on the temperature. The reaction rate is limited by the catalytic behaviour and the heat resisting properties of the materials used.

**4951 National project. Nuclear steelmaking in Japan.** Shimokawa, K.; Tsuruoka, K.; Masada, E. (Engineering Research Association of Nuclear Steelmaking, Tokyo (Japan)). pp vp, Paper 23 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

In July of 1973, a large scale national project for nuclear steelmaking started. The project will take six years and cost about 8,000 million yen. The main research organization is the Engineering Research Association for Nuclear Steelmaking. The association is studying a total system and five sub-systems, which are heat exchanger, superheat resisting alloys, iso-heat materials, reducing gas and reduced-iron pellet manufacture. The object and outline of this poject are discussed.

**4952 Use of nuclear heat in the iron and steel industry.** Barnes, R.S. (British Steel Corp., Sheffield); Decker, A.; Coche, L. pp vp, Paper 20 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Some of the activities related to nuclear steel making which have been carried out all over the world in the last five years and the principal factors which led to the formation in September 1973 of the European Nuclear Steelmaking Club are described. A description of the club is given together with its present and proposed activities. The activities of a Working Party on the Energy Requirements of Iron - and Steelmaking Processes are summarized. Variations of the blast furnace - oxygen steelmaking process route and various processes involving the gaseous reduction of iron ores followed by electric arc-furnace steelmaking are compared in relation to their total energy comsumption. The proportion of the energy that could be obtained from a nuclear reactor is identified, both when the reactor is integrated with the steel plant and when it is separated. The activities of a Working Party established to study the production of reducing gases for steelworks use are reviewed. Some possible future configurations for the inter-connection of steel plants with high temperature nuclear reactors are considered.

**4953 HTGR design for process heat applications.** Bell, F.R.; McEachern, D.W.; Morse, D.C. (General Atomic Co., San Diego, Calif. (USA)). pp vp, Paper 24 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Studies have been carried out at General Atomic Company on the design of an HTGR system to provide heat input to a

hydrocarbon reformer in which methane and/or other hydrocarbons react endothermically with steam to produce hydrogen. Hydrocarbon reforming can be used to provide hydrogen for coal gasification, iron ore reduction, petroleum refining, ammonia production, and other chemical and industrial processes. Helium temperatures somewhat above those found in present-day HTGRs are required for hydrocarbon reforming. A reformer inlet helium temperature of 880°C has been used in most of the studies reported here, and there are some incentives to increase this temperature further. Reactor core studies have shown that there are several modifications to the core design or the fuel management scheme which offer gas temperature increases to 880°C or above without requiring any increase in peak fuel temperature.

**4954 Fission products problems in a heat process plant.** Brisbois, J.; L'Homme, A. (CEA Centre d'Etudes Nucleaires de Saclay, 91 - Gif-sur-Yvette (France). Service des Etudes Mecaniques et Thermiques). pp vp, Paper 33 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The use of a nuclear reactor to produce hydrogen raises the problem of the release of fission products either directly to the environment or indirectly by contamination of the hydrogen, which is for use in homes and factories. Levels are indicated to which this release must be limited. The radionuclide release from a heat process plant is then estimated and compared with that from an HTR power plant of similar size. Finally some improvements in the system are discussed and their efficiency is estimated. It is concluded that an intermediate circuit between the primary and the chemical circuits, overpressured with respect to the primary cicuit, should reduce the radionuclide release to below the accepted level.

**4955 Survey of appropriate endothermic processes for association with the HTR.** Brown, G.; Harrison, G.E. (Humphries and Glasgow Ltd.); Gent, C.W.; Plummer, J. pp vp, Paper 3 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From Internation conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Emphasis is placed on association of the HTR system as a heat source with chemical processes requiring temperatures up to 850 to 900° C, corresponding to a reactor coolant temperature of 950° C, though processes requiring temperatures up to 1100° C and above are reviewed. Particular attention is given to processes for the production of hydrogen-containing gases, including coal/lignite gasification which has been the subject of a recent study. Rising fuel prices make the HTR an attractive proposition if design concepts and materials can be developed to match the requirements. Other appropriate endothermic processes considered are oil processing, including tar sands and shales, and also energy production. Since the full temperature range of the reactor system must be utilised mention is made of low grade heat uses. Even very large chemical works have relatively small energy requirement by nuclear heat standards and adoption of the HTR as a heat source is likely only if it is associated with a large chemical/metallurgical complex or with the processing of a natural resource.

**4956 Need and market prospects for HTR process heat.** Caprioglio, P. (Commission of the European Communities, Brussels (Belgium)). pp vp, Paper 1 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

For nuclear energy to eventually replace fossil fuels it will be necessary in the large non-electrical energy market to achieve two aims, higher temperatures and economic production of flexible multi-purpose energy resources to satisfy the many diverse needs of the small users. The advantages and potential of the HTR are stressed. Economic aspects of hydrogen production are considered briefly.

**4957 Pebble-bed type HTR with a gas outlet temperature of 950°C as a nuclear heat source for chemical process applications status and future development requirements.** Fischer, R (Gesellschaft fuer Hochtemperaturreaktor-Technik m.b.H., Bensberg (F.R. Germany)); Kugeler, K. pp vp, Paper 29 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The status of the pebble-bed HTR is described. For investigating its feasibility and commercial prospects for process heat a design using the OTTO (once through then out) loading scheme was adopted, in which the pebbles are not recirculated but are unloaded on reaching the bottom of the core. The influence on plant design of the higher helium outlet temperature, important to the equalisation of radial power and temperature profile of the core and also of fuel element burn-up are discussed. Modifications to fuel elements and reactor components are described and some areas where further development is needed are indicated.

**4958 Advantages of hydrogen as an energy source.** Halstead, C.J. (Shell International Gas Ltd.); Eden, P.M. pp vp, Paper 36 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

General considerations relating to hydrogen as a possible major source of energy in the future are outlined. In addition, some of the economic implications of using hydrogen are compared with those of other energy forms. Possible methods of production and safety aspects are discussed.

**4959 Large scale experiment tests of the heat linkage between HTR and steam/methane reforming process.** Harth, R.; Von der Decken, C.B.; Fehlhaber, K. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany). pp vp, Paper 48 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The EVA Pilot Plant of the KFA Julich has been operating since the beginning of 1973. The heat linkage between HTR and steam/methane reforming process is investigated at an industrial reforming tube. Technical data and constructional details of the plant and a survey of the present results are given.

**4960 Basic studies for the reformer calculation model.** Hoehlein, B.; Von der Decken, C.D. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany)). pp vp, Paper 8 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The results of the large scale experimental tests concerning the heat linkage between the HTR and the Steam Reforming Process will be entered into a computer program enabling the identification of optium data for future industrial reforming plants. The computer program is based on a mathematical model which is planned to represent the complete reforming process with all the operating parameters such as pressure, temperature, heat flux, mass flow, gas composition, and geometrical sizes of tubes and catalysts. The input data required on the kinetics of the reforming process are developed in a separate small testing plant running parallel with the experiments in EVA. The task of this small testing plant is to examine a differential section of a reforming tube particularly with regard to the kinetics of these reactions at pressures up to 50 bar and temperatures up to 1270°K.

**4961 New nuplex concept by HTR.** Iizima, S. (Industrial Location Centre (Japan)); Yoda, Y. pp vp, Paper 51 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

As a method of preserving energy and resources a new nuplex concept is described which is composed of a utility system, a utility back-up system and an integrated wastes disposal system. The energy is provided by high temperature reactors of helium output temperature of 1000°C from which are provided hydrogen, electric power and thermal energy. The object is the well-balanced development of a local district and will involve heavy industries, food production, domestic heating and waste disposal, and other systems.

**4962 Technical problems of nuclear steam reforming.** Kugeler, K.; Kugeler, M.; Niessen, H.F. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany). Inst. fuer Reaktorentwicklung). pp vp, Paper 9 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

It is shown that there are many applications for nuclear heated steam reformers. Technical problems of helium heated steam reformers are discussed; heat transfer for helium and for process gas, stresses in reformer tubes, hydrogen and tritium diffusion contamination and plate out on reformer tubes, design questions of nuclear heated steam reformers and description of a typical steam reformer design. A short comparision of conventional and helium heated steam reformers is also given.

**4963 Chemical cycles studied by Gaz de France for production of nuclear hydrogen as a future energy vector.** Pottier, J.; Souriau, D. (Gaz de France, 75 - Paris). pp vp, Paper 14 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

After a comparision of the production of hydrogen by electrolysis and from chemical cycles, a description is given of the potassium cycle studied by Gaz de France, with the basic cycle serving as a support for studying the interface between the nuclear reactor and the chemical reactor. Problems of hydrogen transmission and storage, based on experience gained with natural gas are then analysed. Finally, the role hydrogen might play in the medium term in moderate production and utilization systems and also how in the longer term, in addition to its specific uses, it could take over some of the present natural gas consumption areas are discussed.

**4964 Economical aspects of industrial power plants for process steam generation with pebble bed HTR in comparison to oil fired units.** Schroeder, G.; Malmstrom, H. (Steinkohlen-Elektrizitaet A.G. (STEAG), Essen (F.R. Germany)); Kugeler, K.; Barnert, H.; Kugeler, M. pp vp, Paper 39 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

The market situation of the process steam demand in the Federal Republic of Germany is investigated. Today the installation of process steam generating nuclear plants with about 5,000 tons per hour capacity would be justified assuming base load operation. Mainly plants of 500 MW and 1,000 MW thermal capacity are needed. A description of the energy flow, of the nuclear steam supply system, and of the plant arrangement of an industrial power plant with HTR pebble bed reactor is given. Safety aspects, particularly at densely populated sites are discussed. A detailed evaluation of steam generating costs, namely capital investment, operating and fuel costs of steam generation by HTR- and oil fired plants for 500 MW and 1,000 MW thermal capacity is performed.

**4965 Characteristics, potential and limitations of HTR as a process heat source.** Womack, E.A. (USAEC). pp vp, Paper 2 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

A secondary process in the replacement of fossil fuels by nuclear power will be the direct application of nuclear power to industrial processes. The high temperature reactor appears to have unique potential for this purpose and the process with the greatest potential appears to be the production of hydrogen by nuclear heat. Characteristics of the first generation HTR systems and current HTGR technology are briefly reviewed. Engineering developments which will be required for successful VHTR systems are considered: these relate to component materials, fuels, core design, new safety issues, and other aspects. Current national programs and future prospects are discussed.

**4966 Role of nuclear steelmaking.** Barnes, R.S. (British Steel Corp. (UK)). *Ironmaking Steelmaking;* **2**: No. 4, 271-278(1975).

The energy requirements of various ironmaking and steelmaking processes are analysed and the proportion which could be supplied by a nuclear reactor is estimated for each process. The issues which led the European Nuclear Steelmaking Club to restrict its initial studies to non-integrated systems are outlined.

**4967 Motivation for and possibilities of using nuclear process heat.** Dietrich, G.; Eickhoff, H.G.; Niehaus, F.; Niessen, H.F. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany). Systemforschung und Technologische Entwicklung). *Nucl. Eng. Des.;* **34**: No. 1, 3-13(Oct 1975).

A reduction in the use of fossil energy carriers on the energy supply sector will be made possible by a more efficient utilization of energy and the commercial application of nuclear energy. High temperature reactors (HTRs) with spherical fuel elements are not only characterized by high conversion rates reducing uranium requirements to a minimum, but they also supply heat at a high temperature level. Besides electricity supply, this will also open up the much larger heat market to nuclear energy. Nuclear process heat can be used for purposes by way of energy transported over long distances or by district heating. It may also be used to cover the heat requirements in refining plants. This is shown by means of a supply strategy for the Federal Republic of Germany using secondary energy carriers. Profitability studies have shown that nuclear process heat has a number of economic advantages over conventional heat generation, which are still supplemented by ecological benefits (e.g. reduction in waste heat, $SO_2$ and $CO_2$ emissions).

**4968 Nuclear and geothermal energy for direct heat supply.** Field, A.A. *Energy World;* No. 22, 5-8(Dec 1975).

By the 1980s, large industrial complexes and urban buildings could be using steam or hot water generated directly by nuclear reactors. Some installations may use boilers burning hydrogen transmitted from nuclear conversion plants. Massive underground storage of water and hydrogen could form energy reservoirs to smooth out seasonal demand. Wider use will be made of the vast geothermal reserves in Europe.

# NUCLEAR REACTOR TECHNOLOGY

**4969** (AEC-tr—7533/9) **Nukleonika.** Translation of *Nukleonika;* **19**: No. 9, 767-850(1974). 74p. (TT—74-54003/9). Dep. NTIS $4.50.

Separate abstracts were prepared for each of the 10 papers included in the English translation of Nukleonika, Volume 19, Number 9. (HDR)

**4970 University papers in the transactions of the American Nuclear Society (ANS).** Duffey, D. (Univ. of Maryland, College Park); Wiggins, P.F. *Trans. Am. Nucl. Soc.;* **23**: 71-72(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4971 New special program in basic nuclear technology and reactor design.** Malaviya, B.K. (Rensselaer Polytechnic Inst., Troy, NY). *Trans. Am. Nucl. Soc.;* **23**: 72(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4972 Development of a university nuclear engineering program.** Andrews, D.G. (Univ. of Toronto). *Trans. Am. Nucl. Soc.;* **23**: 72-73(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4973 Nuclear engineering technology: two-year associate degree program, Phase I.** Penkala, J.L. (Pennsylvania State Univ., University Park). *Trans. Am. Nucl. Soc.;* **23**: 82-83(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4974 Plan for nuclear education at the associate degree level.** Mandeville, C.E.; Daavettila, D.A.; Caspary, G.J.; . (Michigan Technological Univ., Houghton). *Trans. Am. Nucl. Soc.;* **23**: 83(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4975 Nuclear education for technicians and technologists at Canadian colleges.** Thompson, R.G. (Seneca Coll. of Applied Arts and Tech., Willowdale, Ont.). *Trans. Am. Nucl. Soc.;* **23**: 83-84(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## THEORY AND CALCULATION

*REFER ALSO TO CITATION(S) 5098*

**4976 Problems in the computer simulation of water cooled-water moderated nuclear reactor.** Szilagyi, B.; Benedek, S.; Homoki, G. *Meres Autom.;* **23**: No. 10, 375-378(1975). (In Hungarian with English abstract).

The development of analog and digital computer simulation models for studying the dynamics of the primary loop in a water cooled-water moderated nuclear reactor is described. With the aid of the models, problems in operation and stability can be studied. 4 refs.

**4977** (N—75-24477) **Absolute intensity of radiation emitted by uranium plasmas.** Jalufka, N.W.; Lee, J.H.; McFarland, D.R.

(National Aeronautics and Space Administration, Langley Station, Va. (USA). Langley Research Center). Apr 1975. 8p. (NASA-TM-X—71942). NTIS $3.25.

The absolute intensity of radiation emitted by fissioning and nonfissioning uranium plasmas in the spectral range from 350 nm to 1000 nm was measured. The plasma was produced in a plasma-focus apparatus and the plasma properties are simular to those anticipated for plasma-core nuclear reactors. The results are expected to contribute to the establishment of design criteria for the development of plasma-core reactors. (Auth)

**4978** (AEC-tr—7533/9, pp 19-28) **On the accuracy of the experimental methods used in the investigations of reactor characteristics in critical assemblies with slightly enriched $UO_2$ fuel and light water moderator. Part I.** Dabrowski, C. (Inst. of Nuclear Research, Swierk, Poland). Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

The development of experimental methods has been reviewed and observed data have been compared with those calculated for light-water lattices of low-enriched uranium dioxide fuel. The observed integral reactor parameters provide a fundamental test on calculation methods. These parameters include: material buckling $B^2$, parameter drho/dH, intracell parameters delta$^{28}$, rho$^{28}$, delta$^{25}$, MCR, xi, spectral indices (SI), and related activation measurements. A neutron balance performed for an experimental 3 percent-enriched $UO_2$—$H_2O$ lattice was used to evaluate the effects of uncertainties inherent in the reactor parameters on k/sub eff/. The reactor parameter accuracies achieved in highly advanced laboratories have been compiled. On this basis recommendations have been formulated concerning the accuracy required in reactor parameters.

**4979** New York; American Nuclear Society (1975).

This standard identifies and describes the specifications for developing, preparing, and documenting nuclear data sets to be used in reactor design calculations. The specifications include criteria for acceptance of evaluated nuclear data sets, criteria for processing evaluated data and preparation of processed continuous data and averaged data sets, and identification of specific evaluated, processed continuous, and averaged data sets which meet these criteria for specific reactor types.

**4980 'progressive poisoning' as a perturbation method for measuring neutron properties in a multiplying medium.** Gambier, G. (Univ de Paris-Sud, France). *Bull. Dir. Etud. Rech., Ser. A;* No. 1-2, (1975). (In French).

The 'progressive poisoning' method is a new perturbation method developed in order to overcome certain difficulties of measuring the reactivity coefficients of a cell to determine its neutron properties. The problem of uncertainty of the inhour equation constant and of the output integral is resolved by using a normalizing poison in the ideal case where the poison quantity tends toward zero. The problem of several secondary effects disturbing the measurement is solved by developing a specific experiment for each secondary phenomenon. The first part of the report describes all the forms of the neutron balance that must be known in order to understand and interpret all the phenomena associated with the 'progressive poisoning' process. The second part gives a detailed explanation of the principle of the proposed method and of measurement methods for all associated effects. The third part presents experimental results obtained by application of the 'progressive poisoning' method in the MARIUS critical facility to a 3.5% enriched, graphite-moderated UO$sub 2$ lattice. The fourth part covers the interpretation of the experiment. In the Appendix, the calculation facilities developed for interpretation of the results are described. 39 refs.

**4981 Formulation of the reflected-reactor point kinetics equations.** Rice, C.K.; Kurstedt, H.A. Jr.; Onega, R.J. (Virginia Polytechnic Inst. and State Univ., Blacksburg). *Trans. Am. Nucl. Soc.;* **23**: 589(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4982 Space—time solutions of multigroup nonlinear reactor dynamics equations.** Nguyen, D.H. (Naval Postgraduate School, Ft. Belvoir, VA). *Trans. Am. Nucl. Soc.;* **23**: 590-591(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4983 Accuracy of the improved quasistatic space—time method checked with experiment.** Kugler, G.; Dastur, A.R. (Atomic Energy of Canada Ltd., Mississauga, Ont.). *Trans. Am. Nucl. Soc.;* **23**: 592(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4984 Analytical method of integrating the thermal-hydraulic conservation equations.** Agee, L.J. (Electric Power Research Inst., Palo Alto, CA). *Trans. Am. Nucl. Soc.;* **23**: 196-197(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4985 Some basic properties of response matrix equations.** Weiss, Z. (ASEA-Atom, Vaesteras, Sweden). *Trans. Am. Nucl. Soc.;* **23**: 198-199(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4986 Spatial and angular assumption qualification in the response matrix method.** McDaniel, C.T. (General Electric Co., San Jose, CA). *Trans. Am. Nucl. Soc.;* **23**: 199-201(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4987 Benchmark calculations for a cylindrical black rod.** McDaniel, C.T. (General Electric Co., San Jose, CA); Biron, D.F.; Choong, P.T.; Kusneriuk, S.A.; Leonard, A.; Loyalka, S.K. *Trans. Am. Nucl. Soc.;* **23**: 212-214(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4988 Neutronic depletion benchmark problems.** Gregory, M.V. (E. I. du Pont de Nemours and Co., Aiken, SC); Weate, B.A.; Wagner, M.R. *Trans. Am. Nucl. Soc.;* **23**: 217-218(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4989 Malfunction detection of the nuclear reactor system by the dynamic data system.** Wu, S.M. (Univ. of Wisconsin, Madison); Chow, M.C.; Cain, D. *Trans. Am. Nucl. Soc.;* **23**: 221-222(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**4990 Stability properties of an equation arising in reactor dynamics.** Infante, E.F.; Walker, J.A. (Brown Univ., Providence). *J. Math. Anal. Appl.;* **55**: No. 1, 112-124(Jul 1976).

The stability properties are investigated for a system of integro-differential equations which can be applied to one-dimensional, homogeneous reactor dynamics studies.

## COMPONENTS AND ACCESSORIES

*REFER ALSO TO CITATION(S) 4931, 5111, 5308*

**4991** (AD-A—011355) **Reliability of reactor components and systems subject to fatigue and creep. Technical report.** Freudenthal, A.M. (George Washington Univ., Washington, D.C. (USA). Inst. for the Study of Fatigue Fracture and Structural Reliability). Jan 1974. Contract N00014-67-A-0214-0011. 82p. NTIS $4.75.

The physical-probabilistic basis for the reliability assessment of structural parts operating at elevated temperatures and therefore subject not only to fatigue -- but also to creep-damage or to a combination of both is developed and discussed. The importance of order-statistics concepts and, in particular, of extreme value distributions in structural reliability analysis is demonstrated. Diagrams facilitating the practical application of the developed concepts in this analysis are presented. (GRA)

**4992** (ORNL/Sub—2913-1) **Flanged joints with contact outside the bolt circle: ASME Part B design rules.** Rodabaugh, E.C.; Moore, S.E. (Battelle Columbus Labs., Ohio (USA)). May 1976. Contract W-7405-ENG-26. vp. Dep. NTIS $4.50.

The ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, gives rules which are subdivided into "Part A" and "Part B". Part A covers flanged joints where contact between flanges occurs through a gasket located inside the bolt holes. Part B covers flanged joints with contact outside the bolt holes. This report (a) summarizes the theory for Part B flanged joints, (b) presents examples which show the significant differences between Part A flanged joints and Part B flanged joints, (c) presents the

available test data relevant to the characteristics of Part B flanged joints, (d) gives listings of two computer programs which can be used to evaluate the characteristics of Part B flanged joints, and (e) gives recommendations for Code revisions and other aspects of Part B flanged-joint design.

**4993 Non-dismountable sealed connections.** (to Bignier-Schmid-Laurent (BSL), 94 - Ivry-sur-Seine (France)). French Patent 2,231,912/A/. 29 May 1973. 7p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France).

The invention relates to a method for manufacturing a non-dismountable sealed connection between two conduits made of non mutually weldable metals. The method is characterized in that its consists in assembling two plates, each of which being of a metal weldable to one of the two conduits, in centrally boring in these plates a circular hole of the same diameter with the conduit inner cross-section, and in that each conduit is welded to its respective plate, coaxially with the respective hole. This can be applied to conduits for the circulation of radioactive substances in the nuclear field.

**4994 Checking device for pipes in which a high pressure fluid is circulated.** Bauerle, R.D.; Pitt, W.A.; White, M.A. (to General Electric Co., Schenectady, N.Y. (USA)). French Patent 2,241,036/A/. 14 Aug 1974. 17p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 16 Aug 1973, USA.

A checking device is described for restricting the movements of a pipe in which a high pressure fluid is circulated, should the pipe happen to be ruptured. The device comprises a U-shaped checking or retaining bar surrounding the pipe, and slightly spaced therefrom at each end of the bar a support member fixed to a frame member of the steam generator and an articulated connection between each of the ends and its respective support-member. The device can be applied to nuclear steam boilers.

**4995 Prismatic shells with hexagonal cross-section.** Krajcinovic, D. (Univ. of Illinois, Chicago). *Int. J. Solids Struct.;* **10**: No. 10, 1069-1089(Oct 1974).

A new discrete-continuous analytical model for prismatic shells with hexagonal cross-section is developed on the basis of the semimembrane shell theory. Final results for stresses are derived in form of simple expressions. The proposed analytical model is checked against test and finite element results. The accuracy is judged to be exceptionally good in all cases examined. It appears that the method provides a simple but powerful tool in design of nuclear reactor subassembly ducts.

**4996 Determination of the neutron- and γ-sensitivity of a Rh-SPN-detector.** Bellman, D.; Hamidian, M.R. (GKSS, Inst. fuer Werkstofftechnol., Geesthacht, Ger.). *Atomkernenergie;* **26**: No. 1, 25-28(1975).

Measurements with a Rh-SPN-detector were carried out to determine the contributions of thermal and epithermal neutrons and gamma radiation to the current signal. The detector was used to measure the neutron flux distribution in a peripheral position of the MTR swimming pool reactor FRG-2 at Geesthacht. The maximum operating power was 15MW. A method is described in order to measure the thermal neutron sensitivity and the γ-sensitivity of the Rh-SPN-detector. 7 refs.

**4997 Materials and corrosion aspects of boilers.** Foster, G.G. (Babcock and Wilcox Ltd., Renfrew (UK)). pp 54-57 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

The significant features of materials and corrosion in boilers are highlighted in this short lecture. Materials employed in both fossil-fuelled and nuclear plant are mentioned with particular regard to tubular component. Corrosion problems both external and internal in these components are discussed with reference for the former to the particular environment associated with the plant covering coal and oil-fired units and carbon dioxide, sodium, water and helium in nuclear plant. Internal corrosion aspects are common to both types of plant, and problems encountered are discussed.

**4998 Component compatibility.** Gibbs, G.B. (Central Electricity Generating Board, Berkeley (UK). Berkeley Nuclear Labs.). pp 39-42 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

Satisfactory performance of in-core components requires compatibility with the reactor coolant. Rates of environmental attack must be measured as a function of temperature, coolant composition, irradiation, and metallurgical condition. The morphology of reaction products should be investigated, since localised attack may have an adverse effect on thin structures. The ability of the oxide to continue to grow at interfaces must also be determined. Reaction rates and the adherence of corrosion products need to be assessed for sensitivity to temperature and strain cycling likely to be encountered in service. Corrosion/wear interactions and static adhesion must also be considered for some components. Finally, if service conditions are likely to be severe, the materials evaluation programme must examine the influence of environment on tensile, creep and fatigue properties.

**4999 Application of composite tubes in power plants.** Toernblom, H.; Egnell, L.; Gullberg, R. (Sandvik AB (Sweden)). pp 58-62 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

Composite tubes with metallurgical bond are now being used on an industrial scale in recovery boilers. Service trials in power plants are viewed and the possibilities to solve fireside corrosion problems in the boiler and superheater sections are discussed. The present and potential future application in nuclear power plants is summarized. A brief presentation of the manufacture and fabrication of composite tubes is made and specific material properties are discussed. Composite tubes are concluded to be an established product and a useful means of meeting conflicting material requirements under severe service conditions.

**5000 Materials problems in nuclear power reactors.** Harries, D.R. (UKAEA Research Group, Harwell. Atomic Energy Research Establishment). pp 11-20 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

The development of nuclear reactors for electrical power generation has been actively pursued by several countries during the past twenty years or so. These reactors have provided a new environment for materials and, as a result, many novel materials problems have been discovered. The principle components in the cores of these nuclear reactors are described briefly and the factors governing the choice of materials for these components are surveyed. In addition, the mechanism whereby neutron irradiation damage is created in non-fissile metals and alloys are summarised and some of the damage phenomena are illustrated. Finally, the technological implications of the phenomena in the design and performance of nuclear power reactors, either in operation, under construction or being planned in the U.K., are highlighted.

**5001 Buffer zone for counterflow preheater.** (to Westinghouse Electric Corp., Pittsburgh, Pa. (USA)). Netherlands Patent 7,500,408/A/. 14 Jan 1975. 8p. (In Dutch).

Priority 15 Jan 1974, USA; 5 figs.

A steam generator is disclosed having a U-shaped tube bundle, which extends upwardly from a tubesheet, and a wrapper encircling the tube bundle, a preheater disposed on the cool leg of the bundle and a distribution plate disposed between the tube sheet and the preheater to form a buffer zone, the buffer zone being effective to prevent cold influent feedwater entering the steam generator from channeling along the tubes and contacting the tubesheet.

**5002 Analysis of moderately thick shells of revolution.** Goldberg, J.E.; Tang, Y.; Pathak, D.V.; Baluch, M.H. (Purdue Univ., West Lafayette, IN). *J. Struct. Div., Am. Soc. Civ. Eng.;* **101**: No. 4, 821-838(Apr 1975).

Using plausible transverse distributions of stress and a functional distinction between the differential transverse shears, a new method is presented for analysis of moderately thick arbitrary shells of revolution. The equations, obtained by a variational procedure, are written as a mixed first-order system for numerical integration. Sample results from two examples are included in the paper.

**5003 Calandria and neutron shield unit for nuclear reactors.** Hewins, J.A. (to UKAEA). British Patent 1,410,332/B/. 15 Oct 1975. 6p.

A construction is described that provides a calandria vessel and neutron shield tank in a single unit. The combined unit can be fabricated in sections and can be readily assembled on site, thereby avoiding transportation difficulties. The unit also avoids the need for accurately positioning a conventional calandria vessel relative to neutron shield tanks so that the calandria tubes are in perfect alignment with the corresponding tubes through upper and lower shield tanks. It is preferred that the calandria tubes be sealed into the aligned passages of the opposed neutron shield tank by welding, but detachable joints, such as glanded joints, may be employed.

**5004 Test loop for reactor coolant pumps.** Pawli, L. (Finnatom, Helsinki). *Nucl. Eng. Int.;* **20**: No. 236, 956-958(Nov 1975).

A loop designed for testing the new reactor coolant pump designed by Ahlstrom of Finland is described, and details are given of the main components and instrumentation. The testing of a full scale prototype of the primary pumps for the Loviisa I PWR, and of the first production unit is described. Brief details are given of manning the loop and the cost and advantages of it are discussed.

**5005 New reactor parts need extensive tests to be sure of quality.** Beatson, C. *Engineer;* **241**: No. 6243, 28-29(13 Nov 1975).

A brief description is given of the testing of steel tubing for nuclear reactors by the manufacturers. The behaviour of defects is studied by pressure testing and creep tests. Ultrasonic pulses are examined by use of the Schheren effect and by computer modelling.

**5006 Content addressable memories in scientific instruments.** De Lotto, I.; Golinelli, S. (CIOC-CNR, Bologna). *Nucl. Instrum. Methods;* **130**: No. 2, 487-490(15 Dec 1975).

The content-addressable-memory feature of a new system designed for nondestructive testing of nuclear reactor pressure vessels based on acoustic emission analysis is presented. The content addressable memory is divided into two parts: the first selects the most frequent events among incoming ones (FES: Frequent Event Selection memory), the second stores the frequent events singled out (FEM: Frequent Event Memory). The statistical behavior of FES is analyzed, and experimental results are compared with theoretical ones; the model presented proved to be a useful tool in dimensioning the instrument store capacity.

**5007 Gray cast iron as a material for reactor technology.** Janakiev, N. *Giessereipraxis;* No. 1-2, 1-4(15 Jan 1976). (In German).

Cast iron lends itself as a material for nuclear reactor shielding. In order to be able to utilize the high compressive strength of gray cast iron, it is recommended to use cast iron types with higher strain characteristics. A cast iron type particularly well suited for this purpose is described; it has a very low silicon manganese content, improved mechanical properties, and a higher ductility than conventional gray cast iron grades. 8 refs.

**5008 Radiation qualification of nuclear reactor components.** Naber, J.A.; Lurie, N.A. (IRT Corp., San Diego, CA). *Trans. Am. Nucl. Soc.;* **23**: 601(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## FUEL ELEMENTS

**5009** (ORNL/NUREG/TM—29) **Characterization of Zircaloy-4 tubing procured for fuel cladding research programs.** Chapman, R.H. (comp.). (Oak Ridge National Lab., Tenn. (USA)). 14 Jun 1976. Contract W-7405-eng-26. 126p. Dep. NTIS $6.00.

A quantity of Zircaloy-4 tubing [10.92 mm outside diameter by 0.635 mm wall thickness] was purchased specifically for use in a number of related fuel cladding research programs sponsored by the Division of Reactor Safety Research, Nuclear Regulatory Commission (NRC/RSR). Identical tubing (produced simultaneously and from the same ingot) was purchased concurrently by the Electric Power Research Institute (EPRI) for use in similar research programs sponsored by that organization. In this way, source variability and prior fabrication history were eliminated as parameters, thus permitting direct comparison (as far as as-received material properties are concerned) of experimental results from the different programs. The tubing is representative of current reactor technology. Consecutive serial numbers assigned to each tube identify the sequence of the individual tubes through the final tube wall reduction operation. The report presented documents the procurement activities, provides a convenient reference source of manufacturer's data and tubing distribution to the various users, and presents some preliminary characterization data. The latter have been obtained routinely in various research programs and are not complete. Although the number of analyses, tests, and/or examinations performed to date are insufficient to draw statistically valid conclusions with regard to material characterization, the data are expected to be representative of the as-received tubing. It is anticipated that additional characterizations will be performed and reported routinely by the various research programs that use the tubing.

**5010 Device for cutting nuclear reactor fuel element sheaths.** Yeo, D. (to Westinghouse Electric Corp., Pittsburgh, Pa. (USA)). French Patent 2,237,280/A/. 14 May 1974. 15p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 14 May 1973, USA.

The invention relates to a method for cutting fuel element cladding. A fuel element is moved past laser emitters in order that the laser radiations cut the fuel element clad along the whole length thereof. The two halves of the thus cut clads are then severed and the fuel is recuperated in a hopper. This can be applied to the extraction of the spent fuel from nuclear fuel elements, with a view to re-using the fuel after reprocessing.

**5011 Locking device for fuel bundles of power nuclear reactors.** Long, John; Flora, B.S. (to Exxon Nuclear Co., Richland, Wash. (USA)). French Patent 2,240,502/A/. 31 Jul 1974. 11p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 8 Aug 1973, USA.

The present invention relates to a locked assembly associated by brace rods and easily dismountable. It comprises a locking sleeve provided with lugs engaged in bores of the upper plate, the sleeve being biased towards the plate by a spring. For dismounting the bundle, the plate is pushed against the action of the springs and each sleeve, provided with flat faces is pivoted until it reaches the unlocking position. A guide member prevents each brace rod from being unscrewed from the lower plate. This can be applied to the remote dis-assembling of the fuel rods of a power reactor.

**5012 Apparatus for loading nuclear fuel pellets.** Kee, R.W.; Denero, J.V. (to Westinghouse Electric Corp., Pittsburgh, Pa. (USA)). French Patent 2,239,740/A/. 1 Aug 1974. 12p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 3 Aug 1973, USA.

The invention relates to an apparatus for loading nuclear fuel pellets, adapted to collect the pellets on a receptacle. The apparatus comprises a pellet feed device adjacent to a base supporting the receptacle provided with grooves, and a pusher device adapted to push the pellets from the feed device into the receptacle until the grooves are filled completely. It is possible to achieve a careful and automatic transfer of the pellets one by one onto a platform where they are aligned prior to being introduced in the active rods.

**5013 Materials in power plants: fuels for reactor systems.** Eldred, V.W. (UKAEA Reactor Group, Sellafield). pp 27-32 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

In nuclear power stations heat is generated by the fission of $U_{235}$ within fuel elements. These fuel elements are quite simple: in the vast majority of stations they consist either of a rod of natural uranium metal (0.7%$U_{235}$) sealed inside a finned magnesium alloys tube (can) or clusters of sealed zirconium alloy or stainless steel tubes (cans) containing short, stacked pellets of $UO_2$ enriched in $U_{235}$. The heat is removed by pressurised $CO_2$ or water or, in the case of the fast reactor, by liquid sodium, flowing past the fuel element. In spite of the basic simplicity of such fuel elements there have been problems in selecting and optimising their constituent materials to withstand, for periods of years, the arduous conditions of temperature, corrosion and irradiation, without developing leaks in the can. Examples are given (mainly from thermal reactor fuel elements, under the headings: compatibility, fuel dimensional stability, can ductility, gas release, thermal conductivity, neutron cross sections, other components) of such problems and of the ways in which they have been overcome or minimised. The range of metallurgical phenomena encountered is emphasized.

**5014 Improvements in or relating to nuclear fuel particles for use in the manufacture of nuclear bodies.** (to Commission of the European Communities, Luxembourg). Netherlands Patent 7,500,854/A/. 24 Jan 1975. 9p. (In Dutch).

Priority 25 Jan 1974, UK, 1 fig.

The invention allows a nuclear fuel body to be formed which satisfies a requirement for heavy metal density without the need for high packing density. According to the invention, a nuclear fuel particle for use in the manufacture of nuclear fuel bodies comprises a kernel of fissile material covered by an inner, relatively thin coating of fission product retaining material, an intermediate, relatively thick coating of fertile material and an outer, relatively thin coating of fission product retaining material.

**5015 Conditioning of nuclear reactor fuel.** (to General Electric Co., Schenectady, N.Y. (USA)). Netherlands Patent 7,504,391/A/. 11 Apr 1975. 17p. (In Dutch).

Priority 12 Apr 1974, USA; 10 figs.

A method of conditioning the fuel of a nuclear reactor core to minimize failure of the fuel cladding is described which comprises increasing the fuel rod power to a desired maximum power level at a rate below a critical rate which would cause cladding damage. Such conditioning allows subsequent freedom of power changes below and up to the maximum power level with minimized danger of cladding damage.

**5016** **Manufacture of fuel elements with $U_3O_8$.** De Souza Santos, T.D.; Haydt, H.M.; Gentile, E.F.; Filho, F.A.; de Quadros, N.F.; Filho, N.F. (Instituto de Energia Atomica, Sao Paulo, Brazil). *Metalurgia (Sao Paulo)*; **31**: No. 217, 793-800(Dec 1975). (In Portuguese).

The article describes an assembly of 360 fuel elements containing natural $U_3O_8$ pellets (33 mm in diameter) cased in aluminum alloy tubes and destined for a subcritical research reactor. The pellets were compressed in hydraulic presses with dies 40.1 mm in diameter and their average density was 7.30+-0.11 g $cm^{-3}$. The total mass of pellets loaded into the tubes was 2,282.8 kg; they were sintered in electric furnaces, with an average daily production of 75 kg. The fuel elements were treated by chemical oxidation for surface protection against corrosion.

**5017** **Computer simulation of fission gas swelling behavior in carbide fuels.** Prajoto; Wazzan, A.R.; Okrent, D. (Univ. of California, Los Angeles). *Trans. Am. Nucl. Soc.*; **23**: 170(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5018** **Semiempirical model for radioactive fission gas release from $UO_2$.** Beyer, C.E. (Battelle Pacific Northwest Labs., Richland, WA); Meyer, R.O. *Trans. Am. Nucl. Soc.*; **23**: 172-174(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5019** **Nonequilibrium analysis of fission gas release and bubble freezing during fast transients.** Griesmeyer, J.M.; Steele, W.G.; Okrent, D.; Chien, S.H.; Wazzan, A.R. (Univ. of California, Los Angeles). *Trans. Am. Nucl. Soc.*; **23**: 174(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5020** **Transient deformation of oxide fuels.** Solomon, A.A. (Purdue Univ., West Lafayette, IN); Yust, C.S.; Packan, N.H. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.*; **23**: 176(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## CONTROL SYSTEMS

*REFER ALSO TO CITATION(S) 5630*

**5021** (CONF-760137—1) **Outline of the CRBRP Reactor Instrumentation System.** Macrae, G. (Westinghouse Electric Corp., Madison, Pa. (USA). Advanced Reactors Div.). 1976. Contract E(11-1)-2395. 26p. Dep. NTIS $4.00.

From International Atomic Energy Agency working party; Risley, United Kingdom of Great Britain and Northern Ireland (UK) (27 Jan 1976).

The paper outlines the design of the principal reactor instrumentation systems associated with the Clinch River Breeder Reactor. In the case of the systems external to the vessel, the design is largely conventional and relies heavily on experience arising from the design of the Fast Flux Test Facility (FFTF). In the case of the In-Vessel systems, the design process was the vehicle for an active debate as to the cost-benefit to be obtained from in-vessel instruments. A brief account is presented of the resulting conclusions about the importance and function of the in-vessel instrumentation in a commercial LMFBR.

**5022** (HEDL-TME—76-11) **High temperature accelerometers for use in radiation and liquid sodium environments.** Boehmer, L.S. (Hanford Engineering Development Lab., Richland, Wash. (USA)). Jun 1976. Contract E(45-1)-2170. 43p. AT.

The report describes work performed in support of Fast Flux Test Facility instrumentation development. The tests described were performed to determine the ability of piezoelectric vibration sensors from a variety of manufacturers to operate in the sodium and radiation environment of a liquid metal cooled fast reactor vessel during startup.

**5023** (ORNL—5170) **Instrumentation and Controls Division annual progress report for period ending September 1, 1973.** Sadowski, G.S. (comp. and ed.). (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-ENG-26. 59p. AT.

Research and development on LMFBR instrumentation and control systems included computer control studies, reactor system surveillance and diagnostics, neutron sensor development, fast reactor subcriticality diagnostics, and thermometry.

**5024** (ORNL/TM—5319) **On-line reactor surveillance based on multivariate analysis of noise signals.** Piety, K.R. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 135p. AT.

A minicomputer based system for monitoring signals from nuclear power plants to provide advanced warning of anomalous conditions has been developed and implemented for on-line applications. A characterization of the reactor state is developed from the analysis of noise signals. During an observation period when normal conditions prevail, the surveillance system utilizes these noise characterizations to form a statistical description of normal reactor behavior. At the conclusion of this observation period, the system examines each new incoming characterization to determine if it differs significantly from the normal description. The overall design of the surveillance system is discussed with the perspective of applications in nuclear power plants. The theoretical basis for the anomaly detection procedure is presented. A detailed description of the implementation of these techniques on a minicomputer is also provided. The performance of the surveillance system has been evaluated extensively. Its effectiveness was demonstrated in three on-line tests. The system proved to be sensitive to plant conditions and experienced negligible difficulty with false alarms.

**5025** (SAND—76-0200) **Sandia Pulse Reactor Fast-Level Scram System.** Domingues, R.S. (Sandia Labs., Albuquerque, N.Mex. (USA)). Jul 1976. Contract AT(29-1)-789. 30p. Dep. NTIS $4.00.

This report describes the operation of the Fast-Level Scram System used at the Sandia Pulse Reactor Facility. Testing, calibration, and system setup are detailed.

**5026** **Operational control and scram procedures in process heat HTRs.** Drescher, H.P. (Bonnenberg und Drescher Ingenieurgesellschaft m.b.H., Juelich (F.R. Germany)). pp vp, Paper 34 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Compared with an electricity generating HTR a process heat reactor differs greatly in relation to reactor control and safety procedures as a result of the higher helium outlet temperatures, and the more complicated multi-purpose heat exchanger systems. The problems arising from the more complicated and sensitive technology are illustrated by the example of a 950°C reactor which heats a steam reformer between 950°C and 750°C and which produces super-heated steam between 750°C and 800°C helium temperature. For such a reactor the necessary differences of scheme of the operational control circuit mainly resulting from the different operating behaviour of the steam reformer and the steam generator units (during operation, starting and stopping the plant) are pointed out. Furthermore the scram procedures have to be designed carefully. Due to the high temperatures after some accidents, e.g. rupture of a steam tube the reactor must be cooled down rapidly, a procedure which causes severe conditions at the heat exchangers. This safety problem and first proposals for the layout of such a scram-=procedure are discussed.

**5027** **Control platform and alarm system.** Heining, U. (Rheinisch-Westfaelisches Elektrizitaetswerk A.G., Essen (F.R. Germany)). *Arch. Tech. Mess. Messtech. Prax.*; No. 472, R88-R89(May 1975). (In German).

1 fig. Short communication only.

**5028** **Study on emergency core cooling.** Ishii, M. (Cent d'Etud Nucl de Grenoble, Fr). *J. Br. Nucl. Energy Soc.*; **14**: No. 3, 237-242(Jul 1975).

Two-dimensional conduction model based on thermal penetration depth and proposed models for transient boiling heat transfer is described and analyzed in graphical, tabular, and equation form. 16 refs.

**5029** **Control of CANDU reactors.** Fieguth, W. (Gellman, Hayward, and Partners Ltd., Toronto). *Trans. Am. Nucl. Soc.*; **23**: 62-63(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5030 Efficient solution method for optimal control of nuclear systems.** Naser, J. A. (Electric Power Research Inst., Palo Alto, CA); Chambre, P.L. *Trans. Am. Nucl. Soc.;* **23**: 219-220(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5031 Computer program for reactivity and power shape control.** Tzanos, C.P. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.;* **23**: 274-275(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## ENVIRONMENTAL ASPECTS

*REFER ALSO TO CITATION(S) 5110, 5707*

**5032** (ORNL/TM—5313) **Comparison between dispersed nuclear power plants and a nuclear energy center at a hypothetical site on Kentucky Lake, Tennessee. Vol. IV. A site selection methodology.** Rosemarin, C.S.; Yaffee, S.L. (Oak Ridge National Lab., Tenn. (USA)). Sep 1976. Contract W-7405-eng-26. 71p. Dep. NTIS $5.00.

A methodology has been developed for selecting suitable sites for development as nuclear energy centers. First, the forty-eight contiguous states were screened on the basis of four variables: (1) seismic stability; (2) distance from projected population centers; (3) adequate water supply; and (4) noninterference with scenic and reserved lands. After location of a surrogate area in north central Tennessee, further screening was performed using 22 variables to find a suitable 75-sq-mile surrogate site within this 1500-sq-mile area. A computer method for screening the surrogate area is presented, and the use of the data for the 22 variables is illustrated.

### SITING

*REFER ALSO TO CITATION(S) 5114*

### RADIOACTIVE EFFLUENTS

*REFER ALSO TO CITATION(S) 5678*

**5033** (CONF-760822—16) **Continuing challenges in nuclear air cleaning.** Moeller, D.W. (Harvard Univ., Boston, Mass. (USA). Harvard Air Cleaning Lab.). 1976. 18p. Harvard Air Cleaning Lab., Boston, MA.

From 14. US ERDA air cleaning conference; Sun Valley, Idaho, United States of America (USA) (2 Aug 1976).

The safe operation of nuclear facilities is heavily dependent upon the adequate performance of air cleaning systems. Although many problems have been solved, new questions and new challenges continue to arise. These are well illustrated by weaknesses in air cleaning and ventilating systems revealed by the Browns Ferry fire, and the need to develop additional data on the reliability of such systems, particularly under emergency conditions, as revealed by the Reactor Safety Study. Assessments of the degree to which engineered safety features can compensate for deficiencies in nuclear power plant sites continue to challenge those involved in risk/benefit evaluations. Additional challenges are being generated by the air cleaning requirements associated with the commercial development of the liquid metal fast breeder reactor.

**5034 Mathematical model of removal of radioactive iodine from the air of air-tight nuclear power plant premises by means of sprinkler systems.** Stolyarov, B.M.; Vasyukov, M.S. *Teploenergetika (Moscow);* No. 9, 49-51(Sep 1975). (In Russian).

A mathematical model of radioactive iodine removal from the atmosphere of nuclear power plant premises, after a leakage of the heat carrier from the first loop, is considered. It is supposed that drops are spherically shaped, there is no boundary layer around the drop, a chemical reaction of the first order takes place upon absorption of radioactive iodine by a solution drop, the concentration of the surrounding radioactive iodine falls in accordance with an exponential law along with the functioning of the sprinkler system.

**5035 Monitoring external radiation around nuclear facilities.** Beck, H.L.; McLaughlin, J.E.; Lowder, W.M. (Energy Research and Development Administration, Washington, DC). *Trans. Am. Nucl. Soc.;* **23**: 597-598(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5036 Determination of $^{16}N$ levels for an operating boiling water reactor.** Dyer, N.C. (Idaho National Engineering Lab., Idaho Falls); Bunting, R.L.; Heath, R.L.; Iotti, R.C.; Ayers, A.R. *Trans. Am. Nucl. Soc.;* **23**: 598-599(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

### THERMAL EFFLUENTS

**5037** (PB—242328) **Heat and moisture conduction in unsaturated soils. Completion report.** Havens, J.A.; Babcock, R.E. (Arkansas Univ., Fayetteville (USA). Water Resources Research Center). Jun 1974. Contract DI-14-31-0001-3804. 117p. (Pub—25). NTIS $5.25.

Mathematical models are developed for the prediction of heat transfer from hot water pipes buried in the soil. Heat transfer in the absence of moisture transfer is described as a function of the difference between the temperature of the pipe and the temperature of the soil surface. The energy balance is used to determine the longitudinal temperature distribution of the water. The method is extended to describe a system of equally spaced, parallel buried pipes. Soil temperature profiles around the pipes are presented. The model is used to calculate the land area that can be heated by an underground piping system carrying cooling water from the condensers of a 1000 MW nuclear-electric plant. (GRA)

## RESEARCH, TEST, EXPERIMENTAL, ZERO-POWER, AND TRAINING REACTORS AND SUBCRITICAL ASSEMBLIES

*REFER ALSO TO CITATION(S) 4888, 4889, 4890, 4891, 4904, 4905, 5025, 5091, 5095, 5096, 5097*

**5038** (AEEW-R—1035) **Experiments with hydrogen-moderated control rods in ZEBRA Assembly 14.** Ingram, G.; Burbidge, B.L.H.; Sanders, J.E. (UKAEA Reactor Group, Winfrith. Atomic Energy Establishment). 1975. 35p.

Zero-power studies of the performance of fast reactor control rods containing both absorber and hydrogenous moderator are described. The absorbers included boron, europium and gadolinium, the moderator being simulated by polypropylene. Reactivity worths significantly greater than those of conventional designs were achieved, the most promising arrangement comprising a boron-carbide annulus enclosing a moderating central region. No evidence for local power peaking was observed for such annular geometries.

**5039** (ANL—76-42) **Reactor physics studies in the Engineering Mockup Critical Assembly of the Fast Test Reactor.** Pond, R.B. (Argonne National Lab., Ill. (USA)). Jul 1976. Contract W-31-109-Eng-38. 98p. AT.

Reactor physics studies in the Engineering Mockup Critical (EMC) assembly of the Fast Test Reactor (FTR) facility are reported. The study included measurements of the neutron spectrum, Doppler effect, sodium-void worth, reaction rates, subassembly worths, material replacement worths, and FTR control, safety, and shim rod worths. Each of these physics studies were made in a clean plutonium (low-$^{240}Pu$) fuel composition environment and a dirty plutonium (high-$^{240}Pu$) fuel composition environment. The fuel studies were in support of determining the attendent effects on operation and safety of utilizing Light Water Recycle (LWR) plutonium fuel in the FTR. Comparison of measured and calculated results are presented. Because of the very complex heterogeneous nature of the FTR, a detailed description of the FTR-EMC and particularly each measurement configuration is presented to aid in the understanding of the sensitivity of the experimental and analytical results to these measurement configurations.

**5040** (ANL-CT—76-38) **Airflow tests of 1/12 the-scale FFTF-HTS/DHX inlet plenum model.** Oras, J.J. (Argonne National Lab., Ill. (USA)). Jun 1976. Contract W-31-109-Eng-38. 53p. AT.

Because testing of the FFTF-HTS/DHX prototype at LMEC revealed lower-than-design heat transfer performance, a 1/12 th-scale model of the DHX inlet plenum was constructed of plexiglas to investigate possible ways of reducing energy losses within the plenum. Airflow measurements and flow-visualization, high-speed motion pictures were taken and analyzed. The results indicate the presence of two recirculation regions in the as-designed plenum, one of which requires an estimated 5.6 percent of the energy supplied to the fluid by the blower to sustain the rotation. Modifications with the potential to eliminate or at least minimize these

recirculation regions were also tested, with the goal of identifying an optimum one which would effect both a more uniform velocity distribution through the tube bundle, and a higher total flowrate than with the prototype configuration. None of the modifications selected produced any significant improvement over the as-designed plenum, but another possible modification which should be at least somewhat superior to any of those selected was identified.

**5041** (COO—3409-6) **Twenty-first annual progress report of the Pennsylvania State University Breazeale Nuclear Reactor, July 1, 1975—June 30, 1976. PSBR 315-497688.** Levine, S.H. (Pennsylvania State Univ., University Park (USA). Dept. of Nuclear Engineering). Jun 1976. Contract E(11-1)-3409. 86p. Dep. NTIS $5.00.

Activities in the following areas are reported: facility operation, education and training; Radionuclear Applications Laboratory; and facility research utilization.

**5042** (HEDL-ARD-FRT—1366) **Analysis of the effect of combined seismic disturbances on fuel pin cladding.** Coffield, R. (Hanford Engineering Development Lab., Richland, Wash. (USA)). 6 Dec 1973. Contract E(45-1)-2170. 7p. AT.

Results of an analysis of the effect of combined seismic disturbances on FFTF fuel pin cladding are presented.

**5043** (HEDL-ARD-FRT—1555) **Performance capability of the FFTF fuel-pins as determined by a cumulative mechanical damage function.** Jacobs, D.C. (Hanford Engineering Development Lab., Richland, Wash. (USA)). Oct 1974. Contract E(45-1)-2170. 146p. AT.

A cumulative mechanical damage function (CDF) was used to analyze the performance capabilities of the FFTF fuel-pin. Particular emphasis was given to ascertain the fuel-pin's design lifetime or to demonstrate that the goal lifetime of 300 effective full power days (EFPD) is achievable. These analyses treated the combined effects of steady state operation, anticipated transients (upset events) and unlikely transients (emergency events). The final results reflect the effects of both the environmental and mechanical histories of the fuel-pin. At present, various portions of the irradiation-environmental data base and the high-temperature property data base for the cladding are incomplete. As additional data become available and as the analytical techniques are further developed, the functional form of the CDF, as well as the results obtained, may change.

**5044** (HEDL-PC—1(Rev.1)) **FFTF reactor plant procedures plan.** (Hanford Engineering Development Lab., Richland, Wash. (USA)). 1972. Contract E(45-1)-2170. 27p. Dep. NTIS $4.00.

The document presented defines the plan to be used to coordinate the preparation, review, approval, and issuance of the operating procedure documents required to ensure safe and efficient operation of FFTF.

**5045** (HEDL-SI—74-1) **Test results on the dynamic testing of expansion type concrete anchors.** Barron, B.; Rice, R.; Stephen, R.M. (Hanford Engineering Development Lab., Richland, Wash. (USA)). Dec 1974. 329p. Dep. NTIS $10.00.

Tests were performed to determine the structural response of commercially available expansion type anchors for the FFTF when subjected to dynamic loadings similar to machine vibrations and earthquakes. The specimens were subjected to tension, shear, and combined shear-tension loads.

**5046** (HEDL-TC—687) **FFTF fuel assembly nozzle development testing.** Richman, R.B.; Fiskum, O.S. (Hanford Engineering Development Lab., Richland, Wash. (USA)). Aug 1976. Contract E(45-1)-2170. 45p. Dep. NTIS $4.00.

Tests in both air and sodium environments indicate that a chromium-plated nozzle is superior to a bare 316 stainless steel nozzle in minimizing wear damage to FFTF fuel assemblies without damaging the long life receptacle liner. Loads during initial withdrawal cycles are similar with either nozzle surface; however, with the stainless steel nozzle and repeated insertions and withdrawals, the loads increase.

**5047** (HEDL-TME—75-49) **FTR fuel assembly vibration tests.** Kinsel, W.C.; Mahoney, J.J.; Sawtelle, G.R. (Hanford Engineering Development Lab., Richland, Wash. (USA)). Aug 1976. Contract E(45-1)-2170. vp. AT.

A series of vibration tests were performed on a prototypic Fast Test Reactor (FTR) fuel assembly for the Fast Flux Test Facility (FFTF) to assess the vibrational characteristics under simulated support and flow conditions. The prototypic 217-pin FTR fuel assembly was tested under simulated reactor flow and fuel duct support conditions using water to simulate the primary sodium coolant. The tests were required because of the difficulty in performing accurate analytical predictions of mode shapes and displacements of the fuel assembly and components due to the turbulent flow conditions and highly complex structural boundary conditions. The test results confirmed that the fuel pins and fuel duct met the FTR design criteria for vibrations. For prototypic FTR conditions the fuel pin displacements were less than 2 mils rms. The fuel pin response spectra were characterized by distinct, highly damped resonances at low flow rates and as the flow rate increased the fluid-forced response dominated until at high flow rates the resonant response was almost completely masked by broad band (Gaussian) fluid forces.

**5048** (HEDL-TME—76-51) **Gamma dose rates for FFTF fuel pins, strip layers, and fuel pin storage and transport box designs.** Strode, J.N.; Smith, R.C. (Hanford Engineering Development Lab., Richland, Wash. (USA)). May 1976. Contract E(45-1)-2170. 65p. AT.

A gamma exposure assessment conducted at Hanford Engineering Development Laboratory (HEDL) as part of the Radiation Exposure Control Technology Program is presented. Gamma dose rates calculated by the PUSHLD computer code, as well as confirmatory measurements, are reported for: (a) individual Fast Flux Test Facility (FFTF) mixed oxide ($PuO_2$—$UO_2$) fuel pins; (b) strip layers containing 9, 17, or 30 (two adjacent 15-pin strips) FFTF pins in width; and (c) proposed FFTF fuel pin storage and transport box designs. The report also addresses the effects of plutonium isotopic composition, age of material, and shielding types and thicknesses.

**5049** (ORNL/TM—4511) **Reactivity surveillance instrumentation for measurements with the FFTF engineering mockup core.** Mathis, M.V.; Mihalczo, J.T.; Pare, V.K. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 258p. AT.

Detection instrumentation and analysis systems were required for a large scale reactivity surveillance experiment which was performed with the enginering mockup core of the Fast Flux Test Facility (FFTF) reactor to evaluate three reactivity measurement methods for application to liquid-metal fast breeder reactors (LMFBRs). These systems were used to test the following reactivity measurement methods: modified source multiplication measurements with the low level flux monitor for refueling (approximately 35 dollars subcritical) the FFTF, noise analysis to 35 dollars subcritical, and inverse kinetics rod drop to approximately 12 dollars subcritical.

**5050** (ORNL/TM—5467) **Concept of spatial channel theory applied to reactor shielding analysis.** Williams, M.L.; Engle, W.W. Jr. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 33p. Dep. NTIS $4.00.

The concept of Channel Theory is used to locate spatial regions which are important in contributing to a shielding response. The method is analogous to the channel theory method that was developed for ascertaining important energy channels in cross-section analysis. The mathematical basis for the theory is shown to be the generalized reciprocity relation, and sample problems are given to exhibit and verify the properties which are predicted by the mathematical equations. Finally, a practical example is cited from the FFTF shielding analysis performed at Oak Ridge, in which a perspective plot of channel theory results was found useful in locating streaming paths around the reactor cavity shield.

**5051** (SAND—75-0657) **Results of the initial test program for the Sandia Pulsed Reactor III (SPR III).** Estes, B.F.; Reuscher, J.A. (Sandia Labs., Albuquerque, N.Mex. (USA)). Aug 1976. Contract E(29-1)-789. 168p. Dep. NTIS $6.75.

This document presents a detailed discussion of the reactor including the mechanical and nuclear design characteristics. Also presented are the complete results of the Initial Approach to Critical and the Zero-and-Low Power testing programs. Reactivity worth measurements are given for such parameters as control element integral worth, Safety Block integral worth, and various materials (polyethylene, copper, lead, etc) as a function of position relative to the core. Subcritical reactivity measurements made during the approach to critical generally proved to be in reasonably good agreement with design values due to the good source-fuel-detector geometry possible with a reactor of this type. Subsequent dynamic measurements for reactivity worths are shown to be in good agreement with calculated results.

**5052** (SAND—76-0161) **Hi-g accelerator system.** Atencio, J.P. (Sandia Labs., Albuquerque, N.Mex. (USA)). Jul 1976. Contract E(29-1)-789. 81p. Dep. NTIS $5.00.

This report describes the design criteria and operational capabilities of the Hi-g accelerator system, a pneumatically operated device. The system was designed to accelerate an experiment package up the experimental tube of the Sandia Annular Core Pulse Reactor. A variety of experimental sizes can be accom-

modated by the system and a wide range of acceleration levels are possible.

**5053** (SAND—76-0281) **Annular Core Pulse Reactor upgrade quarterly report, January—March 1976.** (Sandia Labs., Albuquerque, N.Mex. (USA)). Jul 1976. Contract E(29-1)-789. 30p. (NUREG—766500). Dep. NTIS $4.00.

The object of the ACPR Upgrade is to arrive at a reactor modification which will provide an increased pulsed neutron fluence in the irradiation cavity without an increased degradation of the pulse duration. The upgraded reactor will also have an increased steady-state neutron flux. The approach to the upgrade modification involves a two-region core concept. The inner region, surrounding the irradiation cavity, consists of a high-heat capacity fuel which will sustain a large fission energy deposition. The outer region consists of a uranium—zirconium hydride fuel similar to the present ACPR fuel. This reactor modification will make use of the majority of the existing reactor structure and can be accomplished in a relatively short time. The ACPR Upgrade project is divided into nine tasks to improve management of the overall project and to maintain close control of the project budget. This report discusses the progress on each task in a separate chapter.

**5054** (SAND—76-5420) **Performance improvement of the Annular Core Pulse Reactor for reactor safety experiments.** Reuscher, J.A.; Pickard, P.S. (Sandia Labs., Albuquerque, N.Mex. (USA)). 1976. Contract E(29-1)-789. 4p. (CONF-761001—2). Dep. NTIS $3.50.

From International meeting on fast reactor safety and related physics; Chicago, Illinois, USA (Oct 1976).

The Annular Core Pulse Reactor (ACPR) is a TRIGA type reactor which has been in operation at Sandia Laboratories since 1967. The reactor is utilized in a wide variety of experimental programs which include radiation effects, neutron radiography, activation analysis, and fast reactor safety. During the past several years, the ACPR has become an important experimental facility for the United States Fast Reactor Safety Research Program and questions of interest to the safety of the LMFBR are being addressed. In order to enhance the capabilities of the ACPR for reactor safety experiments, a project to improve the performance of the reactor was initiated. It is anticipated that the pulse fluence can be increased by a factor of 2.0 to 2.5 utilizing a two-region core concept with high heat capacity fuel elements around the central irradiation cavity. In addition, the steady-state power of the reactor will be increased by about a factor of two. The new features of the improvements are described.

**5055** **Review of experiments for research reactors.** *Annu. Book ASTM Stand.;* No. 401, 10p(1974).

This standard establishes guidelines for the review and approval of experiments performed at research reactor facilities. This standard identifies the major areas that shall be reviewed for each experiment to ensure that it (a) falls within the limits delineated in the Technical Specifications, (b) does not present an unreviewed safety question as defined in 10 CFR Section 50.59 $\pi 2^{-}$, (c) does not consitute a threat to the health and safety of any individual or groups of individuals, and (d) does not constitute a hazard to the reactor facility or other equipment. In addition, this standard recommends a system for classifying experiments to establish levels of review and approval commensurate with the level of risk inherent in the experiment.

**5056** **Quality control for plate-type uranium-aluminum fuel elements.** *Annu. Book ASTM Stand.;* No. 398, 7p(1974).

This standard sets forth general requirements for the establishment and execution of a program designed to verify that the quality of plate-type uranium-aluminum fuel elements being purchased for research reactors conforms to the requirements of the contract and applicable technical documents, including specifications, standards, and drawings. The quality verification program prescribed comprises the elements of an inspection system, including planning, documentation, surveillance, inspection, testing, and certification. This document also includes elements of inspection control, test and measuring equipment, nonconforming items, and corrective actions.

**5057** (HEDL-HWS—1506B(Pt.4)(Rev.0)) **Design specification: FFTF Post-Irradiation Open Test Assembly (PIOTA) pressure boundary.** (Hanford Engineering Development Lab., Richland, Wash. (USA)). Apr 1974. Contract E(45-1)-2170. 20p. AT.

This specification establishes the design requirements for the pressure boundary subassembly (PBS) portion of the Post-Irradiation Open Test Assembly (PIOTA). This assembly forms a portion of the pressure boundary for the Fast Flux Test Facility (FFTF) nuclear reactor pressure vessel located on the Hanford AEC Reservation near Richland, Washington.

**5058** **Development works of experimental HTGR for multipurpose use at JAERI.** Ishikawa, H.; Ishihara, T.; Miida, J.; Yatsurugi, T.; Shimokawa, J. (Japan Atomic Energy Research Inst., Tokyo). pp vp, Paper 52 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

Japan Atomic Energy Research Institute (JAERI) plans to complete an experimental gas cooled reactor (50 MW(t), outlet temperature of reactor 1,000°C). Research and development work is proceeding including the design study, development of fuel and structural materials, and high-temperature technology with helium gas loops. The conceptual design of the reactor, construction and operation experience of out-of-pile high temperature helium gas loops, development of reactor fuels and high temperature materials, and also construction plans of an in-pile loop (OGL-1) are described.

**5059** **Testing of ENDF/B-IV with GCFR design codes through analysis of critical experiments.** Hess, A.L.; Moore, R.A.; Mathews, D.R. (General Atomic Co., San Diego, CA). *Trans. Am. Nucl. Soc.;* **23**: 565-566(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5060** **Streaming effects in the analysis of sodium void measurements in ZPPR.** Beck, C.L.; Collins, P.J.; Grasseschi, G.L.; Lineberry, M.J. (Argonne National Lab., Idaho Falls, ID). *Trans. Am. Nucl. Soc.;* **23**: 567-568(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5061** **Investigation of blanket plutonium in ZPPR-4 of the demonstration reactors criticals program.** Hitchcock, J.T.; Hartman, A.K. (General Electric Co., Sunnyvale, CA). *Trans. Am. Nucl. Soc.;* **23**: 568(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5062** **Evaluation on expansion worth implied from small-sample reactivity measurement.** Lee, B.W.; Russell, C.S.; Hitchcock, J.T. (General Electric Co., Sunnyvale, CA). *Trans. Am. Nucl. Soc.;* **23**: 568-570(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5063** **Spatially dependent gamma transport cross sections.** Grimm, K.; Meneghetti, D. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.;* **23**: 571-572(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5064** **Energy depositions in EBR-II elastic moderation of neutrons.** Meneghetti, D.; Phillips, K.E. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.;* **23**: 572-573(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5065** **Analysis of burnups in experimental fuel elements irradiated in EBR-II.** Kucera, D.A. (Argonne National Lab., IL); Meneghetti, D; Ebersole, E.R. *Trans. Am. Nucl. Soc.;* **23**: 573-574(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5066** **Calculational analysis of EBR-II power dosimetry test.** Franklin, F.C. (Argonne National Lab., IL); Ebersole, E.R. *Trans. Am. Nucl. Soc.;* **23**: 574-575(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5067** **Error analysis of the EBR-III rod-drop technique.** Foltman, A.J. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.;* **23**: 592-593(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5068 Improved drop-rod calibration for the EBR-II rod-drop tests.** Foltman, A.J. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.;* **23**: 594(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5069 Review of methods for analysis of neutron streaming in the Fast Flux Test Facility reactor design.** Mynatt, F.R. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.;* **23**: 622-623(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5070 Systematic variation of threshold reaction rates in EBR-II.** Lippincott, E.P.; Combs, B.L.; Davis, A.I. (Hanford Engineering Development Lab., Richland, WA). *Trans. Am. Nucl. Soc.;* **23**: 636-637(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5071 SLOWPOKE nuclear reactor as a facility for teaching the dynamic behavior of critical systems.** Hewitt, J.S. (Univ. of Toronto); Robitaille, H.A.; Simpson, G.L.; Hancock, R.G.V. *Trans. Am. Nucl. Soc.;* **23**: 74-75(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5072 Graphite matrix fuels for pulsed reactors.** Marion, R.H.; Karnes, C.H.; Morris, F.M.; Reuscher, J.A. (Sandia Labs., Albuquerque, NM). *Trans. Am. Nucl. Soc.;* **23**: 132(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5073 Development and testing of Beo—$UO_2$ fuel for pulse reactor applications.** Pickard, P.S. (Sandia Labs., Albuquerque, NM); Sasmor, D.J.; Coats, R.L.; Holt, J.B. *Trans. Am. Nucl. Soc.;* **23**: 132-133(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5074 Scanning electron microscope examination of a type-316 stainless-steel cladding breach in an EBR-II Mark-II fuel element.** Eikum, A.K.; Koenig, J.F.; Williamson, M.H. (Argonne National Lab., Idaho Falls, ID). *Trans. Am. Nucl. Soc.;* **23**: 135-136(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5075 Helium profiles across fast reactor fuel pin cladding.** Farrar, H. IV (Atomics International, Canoga Park, CA); Hunter, C.W.; Johnson, G.D.; Lippincott, E.P. *Trans. Am. Nucl. Soc.;* **23**: 156-157(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## PLUTONIUM AND ISOTOPE PRODUCTION, CHEMONUCLEAR, MATERIALS TESTING, AND MATERIALS PROCESSING REACTORS

**5076 Response matrix method development program at Savannah River Laboratory.** Sicilian, J.M. (E.I. duPont de Nemours and Co., Aiken, SC). *Trans. Am. Nucl. Soc.;* **23**: 201(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## PROPULSION REACTORS

**5077 Linear programming design of multivariable feedback controllers for the Nerva nuclear engine.** Porcelli, G. (Fairchild Space and Electron Co., Germantown, MD). *IEEE Trans. Autom. Control;* **AC-19**: No. 5, 537-541(Oct 1974).

The design problem is solved in two steps. The first step consists of an open-loop optimization in which LP is used to determine the plant input vector profile which optimizes the plant response to a specified demand. The second step, also implemented by LP, produces the controller parameters (a matrix of constant gains) and consists of an optimum fitting, through the feedback controller, of the input and feedback error vector profiles determined in the first step. The performance criterion used is the minimum Integral Weighted Absolute Value.

**5078 Comparison of measured and calculated $^{16}N$ activity in water.** Sun, J.B.; Warren, H.D. (Babcock and Wilcox Co., Lynchburg, VA). *Trans. Am. Nucl. Soc.;* **23**: 599-600(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

### NUCLEAR SHIPS LICENSING AND REGULATION

**5079 Official Notice on the Scope of Application of the International Convention of 1960 on the Protection of Human Life at Sea of August 15th, 1975.** *Bundesgesetzblatt, Teil 2;* No. 54, 1226(Sep 1975). (In German).

Short communication only.

## REACTOR SAFETY

*REFER ALSO TO CITATION(S) 4869, 5187*

**5080 (ANCR-NUREG—1301) Quarterly technical progress report on water reactor safety programs sponsored by the Nuclear Regulatory Commission's Division of Reactor Safety Research, October—December 1975.** (Idaho National Engineering Lab., Idaho Falls (USA)). May 1976. Contract E(10-1)-1375. 165p. Dep. NTIS $6.75.

Light water reactor safety activities performed during October—December 1975 are reported. The blowdown heat transfer tests series of the Semiscale Mod-1 test program was completed. In the LOFT Program, preparations were made for nonnuclear testing. The Thermal Fuels Behavior Program completed a power-cooling-mismatch test and an irradiation effects test on PWR-type fuel rods. Model development and verification efforts of the Reactor Behavior Program included developing new analysis models for the RELAP4 computer code, subroutines for the FRAP-S and FRAP-T codes, and new models for predicting reactor fuel restructuring and zircaloy cladding behavior; an analysis of post-CHF fuel behavior was made using FRAP-T.

**5081 (ANL-CT—76-35) Acoustic detection of boiling in the Sodium Loop Safety Facility in-reactor experiment P1.** Carey, W.M.; Anderson, T.T.; Bobis, J.P. (Argonne National Lab., Ill. (USA)). Jun 1976. Contract W-31-109-Eng-38. 54p. Dep. NTIS $4.50.

Acoustic data were obtained from two high-temperature lithium niobate microphones on the loop background noise and transient pressure pulses during the Sodium Loop Safety Facility (SLSF) P1 in-reactor experiment. This experiment simulated an LMFBR loss-of-piping-integrity (LOPI) transient on a nineteen element, end-of-life, enriched-$UO_2$ fuel assembly. The microphones were exposed to liquid sodium at a distance 4.85 meters above the reactor core at temperatures between 315° and 590°C. The distance and location of the microphones in the P1 Test Train provided an attenuative transmission path which was undesirable for optimum acoustic detection of sodium boiling and fuel failure. The data gathered on the loop background noise was observed to be dominated by pump and electrical noise at frequencies below 1.5 KHz and appeared to be dominated by flow induced local turbulence noise at higher frequencies. During the period of time that the sodium in the fuel assembly was at its saturation temperature 943°C (1730°F), as indicated by the wire wrap thermocouples, several discrete pulses were observed with peak-to-peak pressure between 3.3 kPa and 7.9 kPa and center frequencies between 360 and 550 Hz. The pulses occurred at two separate gradually increasing repetition rates. These observations appear to be consistent with the result of an impulsive forcing function interacting with a band passed Helmholtz resonator. These data are consistent with the hypothesis that sodium boiling occurred in the P1 fuel assembly, resulting in the formation of individual voids that collapsed upon reaching the subcooled sodium. These data provide pertinent information regarding the feasibility of sodium boiling detection and may provide additional insight into the dynamics of the void behavior.

**5082 (BMI-NUREG—1949) Reactor safety program applications and coordination. Task 1. Steam—water mixing program and system hydrodynamics. Task 55. Quarterly progress report, January—March 1976.** Cudnik, R.A.; Flanigan, L.J.; Carr, J.A.;

Denning, R.S. (Battelle Columbus Labs., Ohio (USA)). May 1976. Contract Ws7405-eng-92. 56p. NTIS $4.50.

Experimental studies are being conducted in a $^1/_{15}$-scale model of a four-loop pressurized water reactor at pressures to 60 psig to extend the understanding of steam-water interaction phenomena and processes associated with a loss-of-coolant accident. A series of penetration studies was undertaken in the $^1/_{15}$-scale, steel vessel model to define the effects of various parameters and operating conditions on water penetration to the lower plenum over a range of reverse core stream flow rates. The parameters investigated included lower plenum pressure level, injection water flow rate and subcooling, and cold leg stream flow. The operating conditions investigated included operation with reduced break area and varied containment back-pressure, operation with fixed intact cold leg steam, and operation with hydraulic communication between the intact cold leg and core steam supplies. Penetration studies were also undertaken in the $^1/_{15}$-scale, transparent vessel model to determine the effect on penetration of operation with the B and W loop arrangement together with direct annulus injection. Data are presented and discussed.

**5083** (BMI-NUREG—1952) **Some insights on the effect of engineered safety features on the risk of hypothetical LMFBR accidents.** Cybulskis, P.; Allgeier, J.P.; Carr, J.A.; Denning, R.S.; Ritzman, R.L. (Battelle Columbus Labs., Ohio (USA)). 21 Jul 1976. Contract W-7405-eng-92. 72p. NTIS.

Analyses have been performed to evaluate the effect of certain engineered safety features on reducing the risk of hypothetical core disruptive accidents in LMFBRs. Consideration has been limited to accidents which are assumed to result in the core meltthrough of the reactor vessel. The consequences of such accidents have been compared for two principal plant designs: one which does not include any specific provisions to accommodate such an accident, and the other which includes an ex-vessel core catcher and a reactor cavity liner system (hot liner). The general characteristics of the plant design which was studied are representative of a small demonstration plant similar to the FFTF. The approach to risk analysis which is based on the development of accident event trees that was used in this study is essentially the same as that used in the Reactor Safety Study (WASH-1400). The scope of the present study was quite restricted, however; the evaluation of the likelihood of an accident that could result in the meltthrough of the primary system was not undertaken. Thus, insight into the potential risk was obtained only on a relative basis. The consequences of the various accident sequences considered were evaluated in terms of the fraction of the reactor inventory of radioactive materials released to the environment as a function of time.

**5084** (BNL-NUREG—21656) **Primary pipe rupture accident analysis for the Clinch River Breeder Reactor.** Albright, D.C.; Bari, R.A. (Brookhaven National Lab., Upton, N.Y. (USA)). Apr 1976. Contract E(30-1)-16. 174p. Dep. NTIS $6.75.

In this report, the thermal transient response of the CRBR to a severe primary coolant flow perturbation, initiated by a rupture of the primary heat transport system piping, is analyzed. This hypothetical accident is studied under the further assumption that the plant protection system does function according to current design descriptions for the CRBR. Although a brief discussion of an unprotected (no scram) pipe rupture accident is presented, the major emphasis of the present report is on the protected accident.

**5085** (BNL-NUREG—50521) **Analysis of transient thermal response in the outlet plenum of an LMFBR.** Yang, J.W. (Brookhaven National Lab., Upton, N.Y. (USA)). May 1976. Contract E(30-1)-16. 41p. Dep. NTIS $4.00.

A two-zone mixing model based on the lumped-parameter approach was developed for the analysis of transient thermal response in the upper outlet plenum of an LMFBR. The one-dimensional turbulent jet flow equations were solved to determine the maximum penetration of the core flow. The maximum penetration is used as the criterion for dividing the sodium region into two mixing zones. The lumped-parameter model considers the transient sodium temperature affected by the thermal expansion of sodium, heat transfer with cover gas, heat capacity of different sections of metal and the addition of bypass flow into the plenum. Numerical calculations were performed for two cases. The first case corresponds to a normal scram followed by flow coast-down. The second case represents the double-ended pipe rupture at the inlet of cold leg followed by reactor scram. The results indicate that effects of flow stratification, chimney height, metal heat capacity and bypass flow are important for transient sodium temperature calculation. Thermal expansion of sodium and heat transfer with the cover gas does not play any significant role on sodium temperature. This two-zone mixing model will be a part of the thermohydraulic transient code SSC.

**5086** (CENPD—229) **Safety-related research and development for C-E pressurized water reactors. 1975 program summaries.** (Combustion Engineering, Inc., Windsor, Conn. (USA)). Jun 1976. 100p. Combustion Engineering, Inc., Windsor, CT.

Short descriptions of safety-related research and development programs which are applicable to Combustion Engineering pressurized water reactors are presented.

**5087** (COO—2512-9) **Liquid—liquid surface impaction. Annual progress report, July 1, 1975—June 30, 1976.** Bankoff, S.G. (Northwestern Univ., Evanston, Ill. (USA). Dept. of Chemical Engineering). 1976. Contract E(11-1)-2512. 18p. Dep. NTIS $3.50.

The critical Weber number for coalescence, when a droplet of Freon-22 or pentane falls on a pool of hot (80-180°C) silicone oil or glycerine, has been determined as a function of pool temperature and droplet size. Using this information, a splash theory for local propagation of a vapor explosion has been formulated, which agrees with intermediate-scale peak pressure data of Henry, et al. A hydrodynamic theory has been constructed for the minimum thickness of the gas film in the approach phase. The Board-Hall theory for fuel-coolant detonation waves has been modified to take into account the presence of a swarm of drops, rather than a single drop. On this basis the existence of a steady-state Chapman-Jouguet wave in either the tin-water or $UO_2$-sodium systems seems highly unlikely. Scoping experiments on Leidenfrost boiling of droplets and pool boiling from liquid metal surfaces have been initiated.

**5088** (COO—2571-5) **Improvement and verification of fast reactor safety analysis techniques. Progress report, March 1, 1976—May 31, 1976.** Jackson, J.F.; Bott, T.F. (Brigham Young Univ., Provo, Utah (USA). Dept. of Chemical Engineering). 1976. Contract AT(11-1)-2571. 22p. Dep. NTIS $3.50.

The initial phase of a study aimed at providing a consistent comparison of work-energy characterization techniques has been completed. The study encompasses a range of reactor sizes and excursion severities. The work-potentials from isentropic fuel expansions were calculated, along with pressure-volume relationships to be used as source terms in detailed energy-partition calculations. A detailed analysis of the heat-transfer from the beaded fuel during the Kiwi-TNT experiment has also been completed. This analysis shows that there is a significant delay in transfer of the heat from the fuel beads to the surrounding graphite. An improved analysis of the experiment that accounts for this heat transfer effect is under way.

**5089** (COO—2781-1) **Fuel Coolant Thermal Interaction Project. Quarterly progress report No. 1, July 1, 1975—September 30, 1975.** Todreas, N.E. (Massachusetts Inst. of Tech., Cambridge (USA)). 19 Nov 1975. Contract E(11-1)-2781. 9p. Dep. NTIS $3.50.

The objective of the work reported is to experimentally and analytically study the dominant mechanism in fuel—coolant thermal interactions which could lead to vapor explosions. The exploration of mechanisms is focused in two areas: (a) mechanisms responsible for fragmentation in molten metal droplet experiments (including assessment of the validity of the proposed spontaneous nucleation mechanism), and (b) thermal stress initiated fracture as a fragmentation mechanism. Work being performed in these areas is briefly described.

**5090** (COO—2781-2) **Fuel Coolant Thermal Interaction Project. Quarterly progress report No. 2, October 1, 1975—December 31, 1975.** Todreas, N.E. (Massachusetts Inst. of Tech., Cambridge (USA)). Mar 1976. Contract E(11-1)-2781. 9p. Dep. NTIS $3.50.

The objective of the work reported is to experimentally and analytically study the dominant mechanisms in fuel coolant thermal interactions which could lead to vapor explosions. The exploration of mechanisms is focused in two areas: (a) mechanisms responsible for fragmentation in molten metal droplet experiments (including assessment of the validity of the proposed spontaneous nucleation mechanism); and (b) thermal stress initiated fracture as a fragmentation mechanism. Work being performed in these areas is briefly described.

**5091** (COO—2781-3) **Fuel Coolant Thermal Interaction Project. Quarterly progress report No. 3, January 31, 1976—March 31, 1976.** Todreas, N.E. (Massachusetts Inst. of Tech., Cambridge (USA)). Apr 1976. Contract E(11-1)-2781. 14p. Dep. NTIS $3.50.

The objective of the continued work on this project is to experimentally and analytically study the dominant mechanisms in fuel coolant thermal interactions which could lead to vapor explosions. The exploration of mechanisms is focused in two areas: (1) Mechanisms responsible for fragmentation in molten metal droplet experiments (here we will include assessment of the validity of the proposed Spontaneous Nucleation Mechanism); and (2) Thermal

Stress Initiated Fracture as a fragmentation mechanism (this mechanism is not considered responsible for the fragmentation of molten metal drops). Work is being performed in both these areas simultaneously and is briefly described.

**5092** (COO—2801-2) **Direct in-vessel applications experiments at Harvard Air Cleaning Laboratory. Progress report, January 1, 1976—March 31, 1976.** Mallove, E.F.; First, M.W. (Harvard School of Public Health, Boston, Mass. (USA)). May 1976. Contract E(11-1)-2801. 14p. Dep. NTIS $3.50.

Experimental research on emergency direct in-vessel air cleaning systems for the LMFBR is described. Results which characterize the aerosol from 1 lb sodium pool fires made in a 90 $m^3$ chamber are presented. The effective use of turbulent agglomeration to enhance aerosol sedimentation is described. The composition of the aerosol as determined by atomic absorption and chemical tests is discussed. Results from small scale sodium aerosol scavenging tests are presented, anticipating large-scale powder dispersal tests to be conducted in the chamber. Plans for testing the sonic agglomeration characteristics of sodium aerosols are discussed.

**5093** (COO—2803-2) **Density and shape factor of sodium aerosol. Progress report, January 1, 1976—March 31, 1976.** Hinds, W.; First, M.W. (Harvard Univ., Boston, Mass. (USA)). May 1976. Contract E(11-1)-2803. 17p. Dep. NTIS $3.50.

Several approaches for characterizing the physical and aerodynamic properties of irregularly shaped aerosol particles are reviewed. Measurements of density modification factor, dynamic shape factor, and particle density using an aerosol centrifuge and a scanning electron microscope are described. Calibration procedures for this characterization method are described and preliminary results reported.

**5094** (CRBRP-ARD—0115) **Clinch River Breeder Reactor Plant. The development and application of a cumulative mechanical damage function for fuel-pin failure analysis in LMFBR systems.** Jacobs, D.C. (Westinghouse Electric Corp., Madison, Pa. (USA). Advanced Reactors Div.). Aug 1976. Contract E(49-18)-12-3;E(11-1)-2395. 216p. AT.

A Cumulative Mechanical Damage Function (CDF) and related analytical procedures are developed for specific application in LMFBR fuel-pin performance analysis. The CDF monitors fuel-pin integrity through the combined effects of steady state and transient operation. The related analytical procedures are devised to give the design lifetime of the fuel-pin, i.e., the time beyond which clad integrity can no longer be assured. The CDF procedure is totally responsive to the fuel-pin design criterion and it reflects all aspects of the fuel-pin's mechanical and environmental histories. Detailed descriptions of the models used to define the mechanical properties and behavioral characteristics of the clad are given as well as the experimental data used in their formulations. The CDF technique as it applies to fuel-pin performance is illustrated by a typical analysis. The parameters used in this illustration are fashioned after those in CRBRP. 43 refeences.

**5095** (HEDL-TI—76019) **Stress analysis, HCDA loads. FFTF-closed loop system: piping and components, Rev. 1.** Collins, M.V. (Hanford Engineering Development Lab., Richland, Wash. (USA)). Jun 1975. Contract E(45-1)-2170. 50p. AT.

The purpose of the document presented is to report stress analysis results for the Fast Flux Test Facility—Closed Loop System for HCDA (Hypothetical Core Disruptive Accident) loading. It is concluded from the analysis and results presented that the design of the CLS "in-module" piping and components satisfied existing requiremets.

**5096** (HEDL-TI—76026) **Bounding protected reactivity insertion events in the FTR.** Schrull, E.D. (Hanford Engineering Development Lab., Richland, Wash. (USA)). 1976. Contract E(45-1)-2170. 22p. AT.

Protected reactivity insertion events are always analyzed using conservative values for reactivity feedbacks which are less negative than the FTR design values. However, for small reactivity ramps, a delay in the overpower scram trip by using more negative feedbacks may produce higher inside cladding temperatures. The definition of a small reactivity ramp rate depends on the initial state of the reactor, but in all instances, cladding temperatures can be bounded by performing two separate computer runs: (1) steady state at the overpower trip setting, and (2) one using the maximum rate of reactivity insertion expected and the most positive feedbacks. These computations bound the range of reactivity insertion events from essentially zero to the largest rate expected.

**5097** (IS—3974) **Numerical solution of a model for nuclear reactor safety analysis.** Strasburger, M.J.; Skank, H.D. (Ames Lab., Iowa (USA)). Aug 1976. Contract W-7405-eng-82. 65p. Dep. NTIS $4.50.

A mathematical model for the Ames Laboratory Research Reactor and proposed safety device electronics is presented, the method of solution is discussed, and results are graphed and tabulated. The model is comprised of a nonlinear system of nineteen differential equations. A derivation of the three ordinary differential equations which describe the safety electronics unique to this project is given. Three accident postulates (slow rod withdrawal, step insertion and ramp insertion) are specified by initial conditions and other parameters. Solution of the model was obtained by using a modified version of GEAR: Ordinary Differential Equation System Solver from Lawrence Livermore Laboratory. The application of GEAR to this problem, and a note on stiffness of the problem is given. Results obtained from the solution of this model indicate the range of performance for the proposed safety electronics, which appears to be adequate. A FORTRAN computer program listing is given.

**5098** (LA—6137-PR) **Transport theory, reactor theory, and reactor safety. Progress report, July 1—September 30, 1975.** Lathrop, K.D. (Los Alamos Scientific Lab., N.Mex. (USA)). Nov 1975. Contract W-7405-Eng-36. 71p. Dep. NTIS $4.50.

Progress in transport theory, reactor theory, and reactor safety research for the first quarter of FY 1976 is reported. Promising new transport inner iteration acceleration schemes have been developed and tested. A Chebyshev outer iteration acceleration from the FX-2 diffusion code has been implemented in TWOTRAN-II. In CTR research a complete theoretical basis has been formulated for the fusion-reaction cross-section data assessment program and a quantitative determination of Tokamak Fusion Test Reactor nuclear data needs is in progress. In HTGR safety research, the independent LASL cross-section processing code system was improved to account for the doubly-heterogeneous character of the HTGR fuel. A new research program (Containment Systems Analysis) was begun during the quarter. A method for computing delayed neutron precursor motion has been developed and implemented in the SIMMER code for analysis of extended core motion during hypothetical core disruptive accidents. Modeling of core disruption phenomena has progressed in several areas. An analytical method has been derived to assess the role of hydrodynamic instabilities in liquid-liquid interactions, and will be used to estimate the heat transferred across an unstable interface. Substantial progress has been made in the development of TRAC, a computer code for analysis of loss-of-coolant accidents in light water reactors.

**5099** (LA-NUREG—6326-MS) **Development of thin shell equations for reactor subassembly dynamics.** Devault, G.P.; Blewett, P.J. (Los Alamos Scientific Lab., N.Mex. (USA)). Apr 1976. Contract W-7405-eng-36. 16p. Dep. NTIS $3.50.

By means of Hamilton's principle the elastic equations of motion for thin cylindrical shells are developed. Explicitly included in these equations are the possibilities of loading due to interior pressure pulses and to thermal stresses. A test problem is considered for the case of a uniform pressure pulse traveling along the axis; an exact analytic solution is compared with the results found by a finite-difference method. The two solutions agree within 1 percent; which agreement is satisfactory for present purposes.

**5100** (NEDO—21297) **Mark II Containment Supporting Program report.** (General Electric Co., San Jose, Calif. (USA). BWR Projects Dept.). May 1976. 85p. Dep. NTIS $5.00.

The primary objectives of this report are to (1) finalize the overall Mark II Containment Supporting Program (2) update the schedule for program completion on the basis of current knowledge and capability and, (3) provide a detailed description of both the projected tests and analyses and a description and reference to the completed tests and analyses that confirm the design objectives of the program.

**5101** (NP—21103) **Status report for anticipated transients without scram for Combustion Engineering reactors.** (Combustion Engineering, Inc., Windsor, Conn. (USA)). 9 Dec 1975. 103p. NTIS.

The NRC staff review of Combustion ATWS analyses included the anticipated transients expected to occur, the initial conditions and system parameters assumed in the analyses, the reliability of systems, the analytical techniques, the results of transient analysis of ATWS events and the design of the Reactor Protection System. Using the requirements of WASH-1270 as a guideline, the staff reviewed each relevant aspect of the Combustion model and analysis. The discussion of anticipated transients is presented, and the initial conditions, system parameters, and operating systems assumed in the analyses of these transients are discussed. The analytical techniques and computer programs are reviewed. An independent calculation conducted by the staff using the RELAP-3B code to determine the pressure within the reactor coolant pressure boundary during a complete loss of main feedwater ATWS event is

described. A set of standard problems is defined for all pressurized water reactor vendors and the Regulatory staff to insure acceptability of computer codes used in all systems transient analyses. The model for calculating water discharge through primary valves is described. The comparison of the Combustion analyses to the requirements of WASH-1270 is presented. Certain outstanding issues are identified which require that Combustion or the applicant provide additional information or modify existing designs.

**5102** (NUREG—0047-4) **Evaluation of pressure drop across area changes during blowdown. Quarterly progress report, October 1, 1975—March 31, 1976.** Weisman, J. (Cincinnati Univ., Ohio (USA). Dept. of Chemical and Nuclear Engineering). Mar 1976. Contract E(11-1)-2152. 14p. Dep. NTIS $3.50.

Transient pressure drops across abrupt area changes are to be determined in a series of blowdown experiments. These tests are to be conducted with Freon 113 as the test fluid in a well instrumented apparatus. During the reporting period nearly all instrumentation needed was received. In addition, the data acquisition system was also obtained. Modification of the test apparatus to place it in the configuration required for initial tests is now largely completed. The void sensors to be used in the first blowdown experiment have been calibrated in the steady state freon loop. The calibrated sensors have been installed in the blowdown apparatus. Development of computer programs for analysis of the expected data continues. Two parallel approaches are being followed and programs for each have been written and are being debugged. Stability problems have been encountered in the finite difference approach but the method of characteristics continues to be promising.

**5103** (ORNL/NUREG/TM—35) **LMFBR aerosol release and transport program quarterly progress report for January—March 1976.** Fontana, M.H.; Adams, R.E.; Kress, T.S.; Parsly, L.F.; Parker, G.W. (Oak Ridge National Lab., Tenn. (USA)). Contract W-7405-ENG-26;NRC-INA-40-497-75. 67p. Dep. NTIS $4.50.

Progress is reported in the areas of capacitor discharge vaporization (CDV) development, small-vessel fuel and fuel-simulant aerosol studies, large-vessel aerosol studies, HCDA bubble-simulant tests, fuel-simulant response to CDV electrical energy deposition, and bubble transport behavior.

**5104** (ORNL/NUREG/TM—41) **Quarterly progress report on the zirconium metal-water oxidation kinetics program sponsored by the NRC Division of Reactor Safety Research, April—June 1976.** Cathcart, J.V. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-ENG-26. 48p. Dep. NTIS $4.00.

Except for scoping tests of the influence of steam pressure on the oxidation behavior of Zircaloy-4, the experimental phase of the reaction rate studies was completed. Kinetic data for the isothermal steam-Zircaloy reaction between 900 and 1500°C (1652—2732°F) are reported, and the parabolic rate constants for the growth of oxide, alpha, and Xi (oxide + alpha) layers as well as that for total oxygen consumption are given in the form of Arrhenius equations. The transient temperature oxidation experiments are described along with scoping tests of the effects of steam impurities and small variations in alloy content. A study of the oxidation of Zircaloy in high pressure steam was initiated, and a final report on our investigation of the diffusion of oxygen in $\beta$-Zircaloy-4 was prepared. The results of a limited number of oxygen diffusivity measurements in oxygen-stabilized $\alpha$-Zircaloy-4 are also reported.

**5105** (ORNL/NUREG/TM—50) **Monthly progress report for July 1976 describing technical assistance work for the Division of Systems Safety, U.S. Nuclear Regulatory Commission.** Sanders, J.P. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-ENG-26. 13p. Dep. NTIS $3.50.

Progress is reported in the development of an HTGR flow distribution code for loss-of-flow and low flow conditions, in the development of the HEXEREI accident analysis code, and in the acquisition of operational data on the Vrain Reactor.

**5106** (ORNL/NUREG/TM—54) **Monthly progress report for August 1976 describing technical assistance work for the Division of Systems Safety U.S. Nuclear Regulatory Commission.** Sanders, J.P. (Oak Ridge National Lab., Tenn. (USA)). Sep 1976. Contract W-7405-ENG-26;NRC-INA-40-545-75. 13p. Dep. NTIS $3.50.

Progress is reported in the development of computer codes for the description of HTGR's under transient conditions.

**5107** (ORNL-SUB—4450-1) **Water tests for determining post voiding behavior in the LMFBR.** Hinkle, W.D. (Massachusetts Inst. of Tech., Cambridge (USA). Energy Lab.). Jun 1976. Contract W-7405-ENG-26-4450. 129p. (MIT-EL—76-005). Dep. NTIS $6.00.

The most serious of the postulated accidents considered in the design of the Liquid Metal Cooled Fast Breeder Reactor (LMFBR) is the Loss of Pipe Integrity (LOPI) accident. Analysis models used to calculate the consequences of this accident assume that once boiling is initiated film dryout occurs in the hot assembly as a result of rapid vapor bubble growth and consequent flow stoppage or reversal. However, this assumption has not been put to any real test. Once boiling is initiated in the hot assembly during an LMFBR LOPI accident, a substantial gravity pressure difference would exist between this assembly and other colder assemblies in the core. This condition would give rise to natural circulation flow boiling accompanied by pressure and flow oscillations. It is possible that such oscillations could prevent or delay dryout and provide substantial post-voiding heat removal. The tests described were conceived with the objective of obtaining basic information and data relating to this possibility.

**5108** (SAND—76-0273) **Fast Reactor Safety Research Program. Quarterly report, January—March 1976.** (Sandia Labs., Albuquerque, N.Mex. (USA)). Jul 1976. Contract AT(29-1)-789. 44p. (NUREG—766501). Dep. NTIS $4.00.

Progress is summarized in the following study areas: (1) prompt burst excursion, (2) post-accident heat removal (PAHR) debris bed, (3) fuel motion detection, (4) PAHR molten pool behavior, (5) equation-of-state high-temperature fuel vapor data, and (6) fuel motion detection equipment for the upgraded Annular Core Pulsed Reactor. (DG)

**5109 Kinetics, heat transfer and engineering aspects of coal gasification with steam using nuclear heat.** Juentgen, H.; Van Heek, K.H.; Duerrfeld, R.; Feistel, P.P. (Bergbau-Forschung G.m.b.H., Essen (F.R. Germany)). pp vp, Paper 12 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

By the use of process heat from high-temperature reactors for the endothermic steam gasification of coal it is possible to save coal as heat supply, to reduce the carbondioxide emission and, in countries with high price rates of coal, to reduce the costs of gas production. The design of an industrial gasifier based on kinetics of coal gasification as well as heat transfer is described.

**5110 Safety and environmental aspects of nuclear process plants.** Knecht, O. (Internationale Atomreaktorbau G.m.b.H. (INTERATOM), Bensberg/Koeln (F.R. Germany)); Schroeder, G. pp vp, Paper 32 of In High temperature reactor and process applications. London; British Nuclear Energy Society (1975).

From International conference on the high temperature reactor and process applications; London, UK (26 Nov 1974).

A stanard HTR as a heat source for different processes is described. Attention is paid to the inherent safety features and some engineered safeguards e.g. the residual heat removal system and the containment. The influence of an underground containment on safety and costs is discussed. The safety of the reactor is assessed by estimating the probabilities and consequences of typical accidents. The contribution of those accidents to the unavailability of the reactor is calculated. Furthermore the question of environmental protection is investigated. Fossil and nuclear process plants are compared and the long range influence of nuclear process heat on the environment is estimated.

**5111 Data acquisition and data processing in the experimental containment facility.** *IRS Kurz-Inf., Reihe D;* **35**: No. 19, 1-9(1975). (In German).

3 figs.; 1 ref.

In the experimental investigations in the field of reactor safety, many individual phenomena must be integrally acquired under difficult conditions. As an example, the measured value acquisition and processing in the experimental investigations on the large experimental facility 'nuclear reactor containment' assigned by the Federal Ministry of Research and Technology are described here.

**5112 Dynamic aspects of nuclear power. III. Remote machinery condition analysis.** Tustin, W. (Tustin Inst. of Tech., Santa Barbara, Ca). *Test;* **34**: No. 5-6, 10-13(1975).

This final article discusses remote machinery condition analysis (MCA) of vital nuclear plant rotating machinery. The emphasis here is on remote sensing of noise and vibration by microphones and accelerometers and how to record and process their output to provide an early warning of malfunction. Sensors will be hardwired to the monitoring system, which is usually located close to the station operator's console. All sensors will automatically be 'interrogated'regularly, at least once per hour. Their signals will automatically be transformed into spectra and automatically compared with 'baseline'spectra stored in computer memory. The computer is told what spectral changes are important on various machines, what changes to watch for. It is programmed to sound an alarm and call for maintenance. It might be pro-

grammed to shut down a machine if for some reason the alarm was ignored. Or, whenever a spectrum changes in a significant manner, the computer might produce hard-copy printouts of past spectra, including the baseline spectrum, along with the latest spectrum. These will aid the operator in reaching decisions and will aid maintenance operations. Normally, alarms sound far in advance of any outright failure, so that repair parts can be obtained and so that manpower can be scheduled.

**5113 Studies on coolant blowdown phenomena by the use of simulated blowdown test facility.** Shimizu, S. *Denki Shikenjo Kenkyu Hokoku;* No. 753, (Jul 1975). (In Japanese).

An investigation was initiated in 1965 to develop information dealing with coolant blowdown and core heat-up phenomena associated with a loss-of-coolant accident in a light water moderated power plant. The prime concern is the rupture of the light water circulation system used to cool the reactor core (fuel assembly), which results in leakage of the water to the outside, damage to the fuel, and meltdown. A simulated blowdown test facility consisting of a reactor vessel, a simulated core using electrically heated elements, pressurized water loops and boiling water loops provided experimental data for evaluating the effects of rupture size and rupture location (top break, bottom break, single break and double-ended break) on the transient behavior of the primary coolant. Major efforts in these experiments were directed to obtaining data on the transient pressure, transient temperature, volumetric ratio of steam to the steam-water mixture (steam void fraction) in the simulated reactor vessel, the flow resistance in the primary system, and the discharge pressure at the break point. The blowdown phenomena resulting from the top and bottom breaks in the BWR coolant system and those resulting from the single and double-ended breaks in the PWR coolant system were analyzed employing a computer. Experimental results and theoretical analyses are presented. In Japanese with English synopsis. 106 refs.

**5114 Advances in the reliability assessment of reactor systems.** Farmer, F.R. (UKAEA Safety and Reliability Directorate, Culcheth). *Atom (London);* No. 230, 218-226(Dec 1975).

A discussion is presented on the problem of how sites may be specified for power reactors in thickly populated countries, such as the U.K. Matters dealt with include the following: classification of sites as remote, semi-urban and urban; accidental releases of radioactivity; scale of probabilities for accidents; status of reliability analysis; comparison of reactor risks with other risks and acceptable risks from nuclear power; the coolant reliability problem; comparison of effort devoted to small accidents as against large accidents; the Systems Relibaility Service and the National Center of Systems Reliability; data analysis; the computerised Event Data Store; collaboration with industry; laboratory type research; pressure vessel testing; effects of an aircraft crash on a reactor; and fast reactor considerations.

**5115 Determination of the type and amount of fission products released in a nuclear reactor accident.** Tadmor, J. (Israel Atomic Energy Commission, Yavne. Soreq Nuclear Research Center). *Health Phys.;* **30**: No. 1, 95-112(Jan 1976).

In case of an accident in a nuclear reactor, it is very important to evaluate promptly the magnitude and composition of release of fission products, in order to take the adequate emergency measures. The present study describes a method of rapid determination of the type and amount of fission products released in a nuclear reactor accident, by measuring the released radioactivity at specific high $\gamma$ ray energy levels (2.4 to 6.6 MeV). The specificity of some fission products (e.g. $^{88}$Br) characterized by emission of high energy $\gamma$ rays, makes possible the rapid determination of the group of fission products released (halogens, volatiles or solids) and the estimation of the amount of release of critical fission products such as $^{131}$I, $^{90}$Sr and $^{137}$Cs. The method allows the detection of the release, both at the source and in the environment, in airborne material and on deposition surfaces, and at different time delays from occurrence of an accident, varying from zero time up to several days. Other advantages and limitations of the method are discussed.

**5116** (NR-tr—004) **Layout and uses of the PATREC-DE code.** Blin, A. (CEA, 75 - Paris (France)). Jan 1976. Translation of SETS—42. 22p. NTIS $3.50.

The principle of the PATREC-DE code is set forth. The code permits calculation of the reliability of complex systems described as failure trees. Recognition is made of simple forms kept in storage in the form of trees with their mathematical equivalents. The program is written in PL/1 language. Specifications for use of the code are given.

**5117 Radwaste buildup in tanks.** Amir, S.J. *Power Eng.;* **80**: No. 6, 64-67(Jun 1976).

A practical method is presented for calculating the radioactivity buildup in collection tanks for nuclear power plants. Fifty radioisotopic properties used in radwaste analysis are presented, along with filter, demineralizer, and evaporator properties.

**5118 In-containment radiation environments following the hypothetical LOCA (LWR).** Bonzon, L.L. (Sandia Labs., Albuquerque, NM). *Trans. Am. Nucl. Soc.;* **23**: 601-603(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5119 Post-LOCA doses to equipment.** Olson, N.C.; Kolar, M.J.; McCarty, J.R. (Gilbert Associates, Inc., Reading, PA). *Trans. Am. Nucl. Soc.;* **23**: 603(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5120 Engineering evaluation of radiation environment in LWR containments.** Warman, E.A.; Boulette, E.T. (Stone and Webster Engineering Corp., Boston, MA). *Trans. Am. Nucl. Soc.;* **23**: 604-605(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5121 Normal operating radiation levels in PWR plants.** Sejvar, J. (Westinghouse Electric Corp., Pittsburgh). *Trans. Am. Nucl. Soc.;* **23**: 605(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5122 CANDU reactor safety systems.** Yaremy, E.M. (Atomic Energy of Canada Ltd., Mississauga, Ont.). *Trans. Am. Nucl. Soc.;* **23**: 63-64(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5123 Design program for occupational dose reduction.** Vivian, G.A. (Ontario Hydro, Toronto). *Trans. Am. Nucl. Soc.;* **23**: 64(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5124 Report on university involvement in nuclear system reliability and safety efforts.** Fussell, J.B.; Cate, C.L. (Univ. of Tennessee, Knoxville). *Trans. Am. Nucl. Soc.;* **23**: 67-68(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5125 Pragmatic view of risk assessment and reliability engineering.** Vesely, W.E.; Cullingford, M.C. (Nuclear Regulatory Commission, Washington, DC). *Trans. Am. Nucl. Soc.;* **23**: 68(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5126 Probabilistic engineering and risk evaluation at the Idaho National Engineering Laboratory.** Eales, E.P.; Balkovetz, F.J.; Stiger, R.R. (Aerojet Nuclear Co., Idaho Falls, ID). *Trans. Am. Nucl. Soc.;* **23**: 68-69(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5127 Risk assessment and reliability engineering.** Lapides, M.E.; Lellouche, G.S. (Electric Power Research Inst., Palo Alto, CA). *Trans. Am. Nucl. Soc.;* **23**: 69-70(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5128 Broadening the application of risk and reliability technology.** Garrick, B.J. (Pickard, Lowe and Garrick, Inc., Newport Beach, CA). *Trans. Am. Nucl. Soc.;* **23**: 70(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5129 Seminar projects in nuclear reactor safety education at the University of Toronto.** Andrews, D.G.; Mohan, P.K.; Naqvi, S.J. (Univ. of Toronto). *Trans. Am. Nucl. Soc.;* **23**: 73(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5130 Prediction of steady-state thermo-hydraulic conditions in water reactor systems for safety analysis.** Srikantiah, G. (Brookhaven National Lab., Upton, NY). *Trans. Am. Nucl. Soc.*; **23**: 183-184(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5131 Propagation of statistical uncertainties through thermal-hydraulic models.** Gay, R.R. (Electric Power Research Inst., Palo Alto, CA); Mazumdar, M.; Chay, S.C.; Marshall, J.A. *Trans. Am. Nucl. Soc.*; **23**: 184-185(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5132 Numerical hydrodynamics treatment of fuel/steel pools with density variations from nearly pure vapor to incompressible liquid.** Abramson, P.B. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.*; **23**: 192-193(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5133 Application of a drift-flux model to blowdown experiments for light-water reactors.** Kroeger, P.G. (Brookhaven National Lab., Upton, NY). *Trans. Am. Nucl. Soc.*; **23**: 194-195(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5134 Nonlinear iterative diffusion-transport solution technique for LMFBR neutronics.** Cahalan, J.E. (Purdue Univ., West Lafayette, IN); Ott, K.O.; Ferguson, D.R. *Trans. Am. Nucl. Soc.*; **23**: 203-205(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5135 Quasistatic treatment of the time-dependent discrete ordinates neutron transport equation.** Smith, L.L. (Los Alamos Scientific Lab., NM). *Trans. Am. Nucl. Soc.*; **23**: 205-206(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5136 Confidence bounds for the top event unavailability of fault trees.** Lee, Y.T.; Apostolakis, G.E. (Univ. of California, Los Angeles). *Trans. Am. Nucl. Soc.*; **23**: 224(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5137 Computation of error propagation in fault trees.** Stevens, C.A. (Science Applications, Inc., La Jolla, CA). *Trans. Am. Nucl. Soc.*; **23**: 224-225(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5138 How finely should faults be resolved in fault tree analysis.** Rowsome, F.H. III. (Bechtel Power Corp., Gaithersburg, MD). *Trans. Am. Nucl. Soc.*; **23**: 225-226(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5139 Implications of information theory for reliability testing of reactor components.** McCormick, N.J. (Univ. of Washington, Seattle). *Trans. Am. Nucl. Soc.*; **23**: 226-228(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5140 Analytical method for constructing confidence bounds of system availability.** Chu, B.B. (Electric Power Research Inst., Palo Alto, CA). *Trans. Am. Nucl. Soc.*; **23**: 228(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5141 Extensions of an adjoint Monte Carlo method for the reliability analysis of a Markov system.** Buslik, A.J. (Brookhaven National Lab., Upton, NY). *Trans. Am. Nucl. Soc.*; **23**: 228-229(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5142 Shutdown release of fission products in LWRs.** Eigenwillig, G.G.; Hock, R. (Kraftwerk Union AG, Erlangen, Ger.). *Trans. Am. Nucl. Soc.*; **23**: 258-259(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5143 Predicting transient fission gas release under GCFR conditions.** Wunderlich, R.C.; Gruber, E.E. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.*; **23**: 276-277(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5144 Gas turbine HTGR safety systems.** Backus, G. (General Atomic Co., San Diego, CA); Ujifusa, D. *Trans. Am. Nucl. Soc.*; **23**: 277(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5145 Preliminary study of molten material/decomposing solid interface conditions.** Larson, D.W.; Lee, D.O. (Sandia Labs, Albuquerque, NM). *Trans. Am. Nucl. Soc.*; **23**: 278-279(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5146 Development of core-retention melting beds for LWRs.** Sowa, E.S.; van Erp, J.B. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.*; **23**: 279-280(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5147 Asymptotic solution for transient temperature responses in charcoal beds.** Niyogi, K.K.; Lin, S.D. (United Engineers and Constructors, Inc., Philadelphia). *Trans. Am. Nucl. Soc.*; **23**: 280-281(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5148 Potential radiological consequences of multiple steam generator tube rupture.** Fray, R.R. (Pacific Gas and Electric Co., San Francisco). *Trans. Am. Nucl. Soc.*; **23**: 281-282(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5149 Deformation predictions of BWR fuel rods under power ramp conditions.** Merckx, K.R. (Exxon Nuclear Company, Inc., Richland, WA). *Trans. Am. Nucl. Soc.*; **23**: 283(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5150 Spontaneously generated heat flux cries.** Henry, R.E.; Leung, J.C. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.*; **23**: 283-285(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5151 Quenching phenomenon in water reactor emergency core cooling.** Wahba, A.B.; Berning, A. (Laboratorium fuer Reaktorregelung and Anlagensecherung, Garching, Ger.). *Trans. Am. Nucl. Soc.*; **23**: 285(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5152 Analyses of precooling parameters for water reactor emergency core cooling.** Chun, M.H. (Brookhaven National Lab., Upton, NY); Chon, W.Y. *Trans. Am. Nucl. Soc.*; **23**: 285-287(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5153 Dynamic analysis of a hydrostructure system.** Takeuchi, K. (Westinghouse Electric Corp., Pittsburgh). *Trans. Am. Nucl. Soc.*; **23**: 287-288(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5154 RATT-1 code for thermal-hydraulic analysis of power channel blowdown.** Martini, R.; Pierini, G.C.; Sandri, C. (CISE, Milan). *Trans. Am. Nucl. Soc.*; **23**: 288-290(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

# ENERGY STORAGE

**5155 Theoretical and practical aspects of energy storage and compression.** Zucker, O.S.F.; Bostick, W.H. (Univ. of California, Livermore). pp 71-93 of In Energy storage, compression, and switching (1976). Bostick, W.H. (ed.). New York; Plenum Publishing Corp. (1976).

The theoretical and experimental aspects of energy storage and compression are reviewed. The role of complementary energy modes combined with nonlinearities in energy compression is described. The need for "coherent nonlinearity" for efficient compression is emphasized. Various fundamental methods for compressions are described. Quantum mechanical limitations are discussed. Energy storage is reviewed from a theoretical and practical point of view with emphasis on new approaches.

## FLYWHEELS

**5156 (ERDA—76-65) Economic and technical feasibility study for energy storage flywheels. Final report to the Energy Research and Development Administration, Division of Conservation Research and Technology.** (Rockwell International Corp., Downey, Calif. (USA). Space Div.). Dec 1975. Contract E(04-3)-1066. 421p. Dep. NTIS $11.00.

The objective of the study was to determine the technical and economic feasibility of flywheel energy storage systems (FESS) for energy conservation in the residential, commercial, industrial, transportation, and utility sectors. Emphasis was placed on utility system applications. Results of the study show that FESS are technically feasible for all sectors examined. It was established that the cost of energy storage is the more important factor in the feasibility of FESS applications. (TFD)

## LIQUEFIED GAS

*REFER ALSO TO CITATION(S) 4466*

## BATTERIES

### DESIGN AND DEVELOPMENT

**5157 Galvanic power supply device with at least one galvanic cell to be activated by addition of an aqueous solution, and method for activating this cell.** Wijnen, M.D.; Boter, P.A. (to Philips Gloeilampenfabrieken NV). German(FRG) Patent 1,596,187/C/. 18 Sep 1975. 6p. (In German).

2 figs.

The purpose of the invention is to make a power supply device whose activable galvanic cell or cells can quickly deliver a relatively large energy relative to the volume of this cell, and whose parts used in delivering power through the cell can be easily replaced by new parts where necessary. The invention, furthermore, deals with foil material to use in a cell of such a power supply device which can replace similar used foil material in the cell.

### PERFORMANCE AND TESTING

**5158 (AD-A—011227) Facility simulation model for advanced BMD systems. Volume IVA. Power module: user's manual. Final report.** Kao, A.; Blackmon, R.; Eng, D.; McDowell, E. (Army Construction Engineering Research Lab., Champaign, Ill. (USA)). Apr 1975. 53p. (CERL-TR-C—28(Vol.4A)). NTIS $4.25.

See also Volume 3C, AD-A—010713, and Volume 4B, AD-A—009748.

This Power Module Volume is divided into a user's manual, a program reference manual, and a program listing. In this user's manual, input formats are outlined for each power system: Diesel engine, gas-turbine engine, turbo-alternator, fuel cells, and batteries. The module calculates the performance characteristics of each system and also selects commercially available power systems from a data base for both diesel and gas-turbine to meet the power output requirements. Five sample problems, one for each power system, illustrate the use of the Power Module. (GRA)

**5159 (AD-A—011231) Facility simulation model for advanced BMD systems. Volume IVC. Power module: program listing. Final report.** Kao, A.; Blackmon, R.; McDowell, E.; Eng, D. (Army Construction Engineering Research Lab., Champaign, Ill. (USA)). Apr 1975. 45p. (CERL-TR-C—28(Vol.4C)). Availability: Available in microfiche only.

See also Volume 4B, AD-A—009748.

This Power Module volume is divided into a user's manual, a program reference manual, and a program listing. In this program listing, the FORTRAN program of one program in the Power Module is documented. This is Program POWERM. (GRA)

**5160 Kinetics and mechanism of deposition of zinc from zincate in concentrated alkali hydroxide solutions.** Despic, A.R.; Jovanovic, D.; Rakic, T. (Univ. of Belgrade). *Electrochim. Acta;* **21**: No. 1, 63-77(Jan 1976).

Galvanostatic investigation was carried out of the kinetics of the reaction on zinc amalgam hanging mercury drop immersed in alkaline zincate solutions at KOH concentrations ranging from 1 to 14 normal. Three kinds of data were extracted: (1) the pseudo-capacitance as a function of overpotential from the portion of the charging curves prior to plateaus, (2) the Tafel plots from quasi-steady state values at the plateaus, and (3) the Sand's products as function of current density from transition times. In (1), the pseudo-capacitance was found to increase with overpotential; in (2), two slopes (60 mV $dec^{-1}$ and 120 mV $dec^{-1}$) were found in the cathodic direction, and a limiting current was found in the anodic one; in (3), the Sand's product was found to decrease with increasing (1). On the basis of the above findings the reaction mechanism was suggested to be of the cece type, with the chemical dissociation of the intermediate univalent zinc complex between the two electrochemical steps as rate-determining. A modification of the method of evaluating the reaction orders was introduced to account for a simultaneous change of more than one activity of reactants in concentrated solutions. Reaction order was found to be 2 with respect to both $OH^-$ ions and water, this result suggesting that the electroactive species is not only reduced in the number of ligands but also dehydrated with respect to the prevailing species. The anodic limiting current appears to be due to the accumulation of Zn(OH) species to cover all the surface free of adsorbed $Zn(OH)_2$. Exchange c.d. and rate constants of all the four steps of the reaction were estimated. 13 figures, 2 tables.

### MATERIALS, COMPONENTS, AND AUXILIARIES

*REFER ALSO TO CITATION(S) 5182*

**5161 Electric storage battery.** Ruben, S. German(FRG) Patent 2,434,193/A/. 6 Feb 1975. 17p. (In German).

6 figs.

A lead—acid battery with the electrodes carried on metal substrates has a reduced weight. A stretching of the positive electrode with the lead oxide on it leads to an increased efficiency of the cell.

**5162 Electrochemically active cadmium mass for galvanic elements.** Ness, P.; von Doehren, H.; Schroeder, H. (to Varta AG). German(FRG) Patent 2,361,905/A/. 26 Jun 1975. 7p. (In German).

The invention is based on the task of making an electrochemically active cadmium mass which can be used as active mass and as discharge reserve in the production of negative electrodes for nickel—cadmium batteries. According to the invention, this problem is solved in that the electrochemically active mass is an intermetallic compound of cadmium and nickel of the type of the 'Hume-Rothery' phase.

**5163 Lithium—aluminum electrode.** James, S.D. (Naval Surface Weapons Center, Silver Spring, MD). *Electrochim. Acta;* **21**: No. 2, 157-158(Feb 1976).

The Li—Al solid alloy has been used as the negative electrode in experimental molten salt secondary batteries. Its rest potential has been studied as a function of composition and temperature. This work describes voltage—time curves for Al wires electrolytically charged with Li and discharged in the LiCl—KCl eutectic melt at 703°K (430°C). These preliminary data show the charging process to be much less polarized than the discharge, which seems to be diffusion limited. 2 figures. (RWR)

### APPLICATIONS

*REFER ALSO TO CITATION(S) 5174, 5175, 5181, 5193, 5196, 5233, 5279*

**5164 Battery charging and replacement station for multicell accumulators of battery-powered vehicles.** Hagen, H.; Laforce, E.

(to Maschinenfabrik Augsburg-Nuernberg (M.A.N.) AG). German(FRG) Patent 2,118,847/C/. 30 Apr 1975. 7p. (In German).

3 figs.

The existing multicell accumulator replacement systems for battery-powered vehicles have the disadvantage that the vehicle must be positioned very accurately between the battery chambers of the replacement station. With non-trackbound vehicles, this is met with considerable difficulties. The present invention claims a charging and replacement station for the multicell accumulators of battery-powered vehicles which allows a fast battery replacement also for non-trackbound vehicles. The multicell accumulators are removed from the vehicle by means of a refuelling cart which can be driven into an opening between two parts of the replacement station designed as battery reception chambers. The technical details of the refuelling cart are described.

# ENERGY MANAGEMENT AND POLICY

**5165 ERDA's job is to throw money at the energy crisis.** Alexander, T. *Fortune;* 94: No. 1, 152-156, 158, 160-162(Jul 1976).

ERDA's operations for the first year and a half are reviewed rather critically under the following topics: suspicions about the AEC; steering clear of Germantown; a marvelous new pork barrel; bad reviews from the Office of Technology Assessment; getting rid of the roadblocks; new products from World War II; help from Admiral Rickover; why the government isn't wise; how to make a bill passable; they've just begun to plan; and the friction is built in. Among Mr. Alexander's conclusions are these: (1) even if ERDA's planners were the wisest of men and their plans were uniformly perspicacious, Congress's tendency to build cross purposes into projects may ultimately defeat them; (2) to some extent, we have institutionalized a three-cornered system in which mutually opposed forces—planning, politics, and market economics—neutralize each other; and (3) with so much internal friction built into the system, any real movement toward resolving our energy problems will be hard to achieve. He further states that "the question is not whether we need an ERDA—we do—but whether we can learn to build some restraint into its plans and operations. ERDA will have to learn how, in getting new technologies into commercial use, to exploit the sensitive intellectual resources of those millions of decision makers that are loosely called 'the market'." (LMT)

## SYSTEMS STUDIES AND TOTAL ENERGY

*REFER ALSO TO CITATION(S) 5200, 5202*

**5166** (BNL—21667) **Dynamic systems analysis of the relation between energy and the economy.** Behling, D.J. Jr. (Brookhaven National Lab., Upton, N.Y. (USA)). Jul 1976. Contract E(30-1)-16. 17p. (CONF-760933—1). Dep. NTIS $3.50.

From 13. Institute of Electrical and Electronics Engineers Computer Society international conference; Washington, District of Columbia, United States of America (USA) (7 Sep 1976).

An integrated system of energy and economic models is developed for use in assessing the energy and economic impact of a wide range of government energy policies. The system incorporates detailed engineering information for a wide range of potential new energy technologies and relates implementation levels of these new technologies to the structure of the energy sector and to such economic aggregates as the level and rates of change of income, output, employment, and prices. Solution of a preliminary version of the system indicates that the real economic costs of a balanced oil import reduction policy of providing additional new energy technology and taxing imported oil will be less than those associated with an oil import reduction policy relying solely on oil import taxes.

**5167** (BNL—50516) **Technical and economic feasibility of U.S. district heating systems using waste heat from fusion reactors.** Karkheck, J.; Beardsworth, E.; Powell, J. (Brookhaven National Lab., Upton, N.Y. (USA)). Feb 1976. Contract E(30-1)-16. 156p. Dep. NTIS $6.75.

In this study district heating systems are shown to be economically attractive for large-scale implementation in the U.S., provided suitable sources of waste heat are available. Fusion reactors appear to be very desirable as sources of waste heat for district heating systems. Since fusion reactors appear to be more environmentally acceptable than fission reactors or coal steam electric plants, they could possibly be located closer to district heat load centers, which should result in substantial cost savings due to lower transmission costs. In this study, CTR distances on the order of 20 miles from urban areas are acceptable in terms of transmission cost. Model district heating systems are designed for nine regions in the U.S. (New York City, Paterson, N.J., Chicago, Philadelphia, Los Angeles, Baton Rouge, New Orleans, Jersey City, and Newark). Estimates are also made as to the implementation and costs to be expected for district heating systems in the U.S. as a whole. The study evaluates the impact of the CRT-district heat option on the U.S. energy system; this was carried out using the BNL BESOM program. It is concluded that two additional markets exist for district heating, those of process heat and air conditioning. (MCW)

**5168** (ORNL/HUD/MIUS—6) **MIUS systems analysis: initial comparisons of modular-sized integrated utility systems and conventional systems.** Samuels, G.; Robertson, R.C.; Boegly, W.J. Jr.; Breitstein, L.; Gant, R.E.; Griffith, W.L.; Meador, J.T.; Miller, A.J.; Payne, H.R.; Segaser, C.L. (Oak Ridge National Lab., Tenn. (USA)). Jun 1976. Contract W-7405-eng-26. 266p. Dep. NTIS $9.00.

This memorandum presents the results of a preliminary study of the economics, fuel requirements, and environmental impacts of Modular Integrated Utility Systems (MIUS) and conventional energy systems. The primary analytical effort was placed on determining the costs and energy requirements associated with several methods of supplying electricity, space heating, domestic hot water, and air conditioning services at sites similar to those in Philadelphia. A total of eleven models are considered. Nine of the models studied are garden apartment complexes; eight have 720 dwelling units, and one has 1080 units. All units have a floor area of 900 $ft^2$ and are arranged 12 units to a building. The other two models are 800-$ft^2$ units in a high-rise apartment building containing 130 dwellings. Gas engines were selected as the prime mover for the total energy systems in the study. The utility grid in the conventional system models is assumed to consist of an equal number of coal-fired and nuclear large base-loaded plants. Emissions of NO/sub x/, $SO_2$, and particulates from the central power station were based on recent federal standards for coal- and oil-fired steam generators with capacities greater than 250 x $10^6$ Btu/hr. Because no Federal standards have been set for CO and hydrocarbons, emissions of these pollutants were estimated from data on four coal-fired steam generators and from data on fuel oil combustion. Data on emissions from gas engines and gas-fired boilers were not readily available at the time of this study; therefore, for this initial comparison of the effects on air quality, the prime movers of electrical generators of the first model a were assumed to be diesel engines, and the fuel for on-site boilers was assumed to be No. 2 fuel oil. Additional information is provided in eleven appendixes.

**5169** (ORNL/HUD/MIUS—20) **MIUS system analysis: comparison of MIUS and conventional utility systems for an existing development.** Hise, E.C.; Boegly, W.J. Jr.; Kolb, J.O.; Meador, J.T.; Mixon, W.R.; Samuels, G.; Segaser, C.L.; Wilson, J.V. (Oak Ridge National Lab., Tenn. (USA)). Jun 1976. Contract W-7405-eng-26. 178p. Dep. NTIS $7.50.

This study was directed toward the application of the Modular Integrated Utility System (MIUS) concept to an existing housing-commercial development (Walden) that is located near Chicago, Illinois. The postulated MIUS (the Live Model) would supply electricity, district heating and cooling, liquid waste treatment, and solid waste disposal to the development. Potable water for human consumption and fire protection were not included in the study. Earlier MIUS modeling efforts were made on models that allowed simpler analysis, but were not representative of actual housing developments. Comparisons of fuel savings, annual costs, and environmental impacts between the MIUS and conventional utility services to the development have been performed. In the Live Model, even though the source of electricity was small (engine-generators having an operating efficiency averaging about 30 percent), the overall fuel utilization was about 62 percent. The overall efficiency of fuel utilization for the conventional utility was only 51 percent. Economic analyses using present marginal cost for incremental services (as of January 1972) indicate that MIUS costs more than would be required to serve the same development conventionally. Environmental impacts of the Live Model are an increase in CO, HC, and NO/sub x/ emissions, but a reduction in $SO_2$ and particulate emissions. In any case, the Live Model will not exceed the Federal Air Quality Standards (FAQS) and the local air quality is not markedly changed from that of the conventional utilities. Impact due to onsite liquid waste treatment is mainly caused by releasing effluent at a different point than a large conventional system since the same, or higher, degree of treatment can be obtained with small plants as can be produced with larger plants.

## ECONOMICS AND SOCIOLOGY

*REFER ALSO TO CITATION(S) 4469, 4470, 5166, 5193, 5224*

**5170** (BNL—21066) **Stochastic model for subregional population projection.** Meier, P.M. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 15p. (CONF-760407—5). Dep. NTIS $3.50.

From Conference on environmental modeling and simulation; Cincinnati, Ohio, United States of America (USA) (20 Apr 1976).

A stochastic method for the projection of subregional population is developed, to be used in conjunction with regional OBERS projections. The model is based on on a Monte Carlo simulation and numerical integration technique to generate probability distributions of future population, given some analytical formulation of population density in urban areas, and is addressed particularly to consulting engineers who must make decisions on design capacity for waste treatment facilities.

**5171** (SSI—1975-022) **Quantifying the costs and benefits of energy.** Lindel, B. (Statens Straalskyddsinstitut, Stockholm (Sweden)). Jun 1975. 20p. (CONF-750697—3). Dep. NTIS (US Sales Only) $3.50.

From Proceedings of energy and the environment - cost benefit analysis; Atlanta, Georgia, USA (23 Jun 1975).

A number of principles that have been developed for cost-benefit assessments in the radiation field are applied to the more general cost-benefit assessment of energy production. Sources of energy may be assessed in relation to a reference practice. If this is done for one and the same electricity production, the main objective is to assess detriments in comparable terms. Detriment rates may be integrated in space and time and might also be expressed in equivalent monetary units. Although there are several practical limitations to any theoretical treatment of the problem, the basic principles may form a useful background to more realistic although more complicated approaches to the task.

**5172** (TEC—75/006b, pp 25p., Task Report 2) **Population projections for the St. Louis and Philadelphia metropolitan regions, 1980—2000.** Sjovold, A.R. Sep 1975.

In Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume II. Task reports on electric car characterization and baseline projections. Final report.

Baseline population projections to the year 2000 for the St. Louis and Philadelphia metropolitan areas are adopted, and study areas are selected for use in electric car impact studies. Projections by various local state and regional agencies in each of the areas are presented and analyzed. Underlying assumptions regarding the components of population change are examined, and fertility assumptions are compared with current trends to determine a baseline projection for electric car impact studies. Driving-age populations are also forecast.

**5173** (TEC—75/006b, pp 54p., Task Report 5) **Economic projections for the St. Louis and Philadelphia regions, 1980—2000.** Eisenhut, J.C. Sep 1975.

In Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume II. Task reports on electric car characterization and baseline projections. Final report.

Business activity in the St. Louis and Philadelphia Standard Metropolitan Statistical Areas (SMSAs) is examined to determine what industry sectors might be affected if conventional cars are replaced by electric cars. There are 12 industry sectors comprising 7.0 percent of the St. Louis area employment and 7.8 percent of the St. Louis area firms. In Philadelphia, there are 16 industry sectors comprising 2.9 percent of the area employment and 7.0 percent of the area firms. The industries are in the general areas of electrical equipment manufacturing, vehicle and vehicle parts manufacturing, petroleum distribution, and the sales and repair of automobiles. Historical trends in the employment, payroll, and number of these firms are extrapolated to the year 2000. These extrapolations are a basis for future work which will show the relative magnitude of changes induced by various levels of electric car use.

**5174** (TEC—75/006c) **Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume III. Task reports on impact and usage analyses. Final report.** Hamilton, W.F.; Eisenhut, J.C.; Fox, H.G.; Martinez, J.R.; Sjovold, A.R.; Tran, K.; Waller, W.E. (General Research Corp., Santa Barbara, Calif. (USA)). Sep 1975. Contract E(04-3)-1119. 338p. Dep. NTIS $10.60.

A study is presented in three volumes, the first containing a comprehensive account of the impacts that electric cars would have on energy use, the environment, and the economy in two urban areas, the remaining two volumes containing task reports documenting the analyses contained in the first volume. The four task reports contained in Volume III cover (1) energy impacts; (2) air quality impacts; (3) resource and environment impacts; and (4) economic impacts. A separate abstract for each of the four task reports was prepared for ERDA Research Abstracts (ERA) and for Energy Abstracts for Policy Analysis (EAPA). (PMA)

**5175** (TEC—75/006c, pp 65p., Task Report 9) **Economic impacts of electric cars in St. Louis and Philadelphia.** Fox, H.G.; Waller, W.E. Sep 1975.

In Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume III. Task reports on impact and usage analyses. Final report.

A study was made of the economic impacts that could be expected to accrue in the St. Louis and Philadelphia Regions in the event electric cars are substituted for internal-combustion-engine automobiles. Life-cycle costs are developed for average, conventional, and low-performance subcompact internal-combustion-engine automobiles and for electric cars with four different types of batteries of the 1980, 1990, and 2000 time periods. The impacts upon regional economic sectors that would be affected by electric car usage are also developed and are expressed as changes in employment, payrolls, and personal income. Findings from a previous electric car study pertaining to the Los Angeles region are presented for contrast and comparison. 3 figures, 33 tables.

## ENVIRONMENT, HEALTH, AND SAFETY

*REFER ALSO TO CITATION(S) 5174, 5224, 5228, 5229, 5271, 5296, 5682, 5683*

**5176** (CONF-760652—2) **Energy, environment, and health: what can we learn from the nuclear experience.** Richmond, C.R. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-Eng-26. 34p. Dep. NTIS $4.00.

From Health Physics Society meeting; San Francisco, California, United States of America (USA) (27 Jun 1976).

The author discusses the fallacy of ever thinking cost-benefit analysis of health and environmental effects can fully be quantified and cautions about premature solutions to the environmental problems of energy supplies. Comparison between nuclear energy and coal relative to environmental assessments is given in hopes that decision-makers may avoid the pitfalls of the past. (PCS)

**5177** (PB—241824) **Development of a trial air quality maintenance plan for the St. Louis AQMSA. Final report.** (Voorhees (Alan M.) and Associates, Inc., McLean, Va. (USA)). Dec 1974. Contract EPA-68-02-1388. 171p. NTIS $6.25.

See also PB—237416.

This report documents the development of a trial air quality maintenance plan for the St. Louis Air Quality Maintenance Study Area. This is one of four such trial plans prepared as part of the development and testing of EPA Guidelines for air quality maintenance planning. The four areas include St. Louis, San Diego, Denver, and Baltimore. The study area in this report includes the city of St. Louis and the seven counties in Missouri and Illinois which comprise the St. Louis SMSA. The preparation of this trial plan included the review of existing state implementation plans, emission inventory analysis and projection, air quality analysis and projection, and the formulation of attainment/maintenance strategies for control of particulates, sulfur dioxide, carbon monoxide, and photochemical oxidants. (GRA)

**5178** (PB—243568) **Environmental Protection Agency Library System Book Catalog. Holdings from August 1973 to December 1974.** (Environmental Protection Agency, Washington, D.C. (USA)). Jan 1975. 479p. (EPA-LIB—75-01). NTIS $12.00.

The U.S. Environmental Protection Agency Library System Book Catalog of holdings from August 1973 to December 1974 has been published in a single volume. The full catalog lists alphabetically by title the complete entry for each book owned by the individual EPA libraries. The indexes to the Book Catalog are in two parts. Part 1, the Author Index, lists each author in alphabetical order. The Subject Index (Part 2) lists, in alphabetical order, the subject headings assigned to the books in the catalog. (GRA)

**5179** (PB—243696) **Radioactivity standards distribution program, 1975. Environmental monitoring series.** (National Environmental Research Center, Las Vegas, Nev. (USA)). Apr 1975. 19p. (EPA—680/4-75/002a). NTIS $3.25.

See also PB—240955.

A program for the distribution of calibrated radioactive samples, as one function of EPA's quality assurance program for

environmental radiation measurements, is described. Included is a discussion of the objectives of the distribution program and a description of the preparation, availability, and distribution of calibrated radioactive samples. Instructions and application forms are included for laboratories desiring to participate in the program. This document is not a research report. It is designed for use by personnel of laboratories participating or desiring to participate in the Radioactivity Standards Distribution Program which is a part of the U.S. Environmental Protection Agency's quality assurance program. (GRA)

**5180** (PB—243805) **Environmental Protection Agency Library System Book Catalog. Holdings as of July 1973. Volume I.** (Environmental Protection Agency, Washington, D.C. (USA)). Dec 1974. 740p. (EPA-LIB—74-06(Vol.1)). NTIS $17.25.

See also PB—243806.

Volume I is the full catalog, listing alphabetically by title the complete entry for each book owned by any of the EPA libraries. The title is printed in bold face type. Directly underneath, left justified, appears the call number (according to the Library of Congress Classification Scheme). At the far right of the same line is the publisher. The next line, in italics, reflects the author(s) and may be followed by an entry showing symposium data, subtitle, series, or other notes (not applicable to each title). The subject headings assigned to the book appear next, indented, one per line. The next line, indented still further, lists the code number for the holding library, pertinent volumes and/or editions, the date(s) of publication and, where appropriate, a call number used by holding library which differs from the Library of Congress classification. (GRA)

**5181** (TEC—75/006c, pp 120p., Task Report 7) **Air quality impacts of electric cars in the St. Louis and Philadelphia metropolitan regions, 1980—2000.** Martinez, J.R.; Tran, K.T. Sep 1975.

In Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume III. Task reports on impact and usage analyses. Final report.

A study was made of the air quality impact of replacing conventional heat engine passenger cars with electric vehicles in the St. Louis and Philadelphia regions for the years 1980, 1990, and 2000. Emissions from both stationary and mobile sources and air quality were estimated for each region with and without electric cars for these three years. In making these estimates, very high levels of electric car use were assumed: replacement of 20, 80, and 100 percent of the conventional passenger cars in 1980, 1990, and 2000, respectively. For both St. Louis and Philadelphia, the results show that use of electric cars would tend to reduce areawide emissions of total hydrocarbons and carbon monoxide. The reductions range from 6 percent in 1980 to 17 percent in 2000 for hydrocarbons, and from 10 percent in 1980 to 18 percent in 2000 for carbon monoxide. The overall effects on particulate emissions were essentially insignificant. Because of the greater demand for electricity induced by electric vehicles, emissions of sulfur oxides tended to increase. For Philadelphia the increases ranged from a maximum of 21 percent in 1990 to a minimum of 3 percent in 2000; for St. Louis, increases in sulfur oxides emissions ranged from 5 percent in 1980 to 14 percent in 1990. In the case of emissions of nitrogen oxides, electric vehicles produced imperceptible effects in Philadelphia. In St. Louis, nitrogen oxides increased 4 percent in 1980 and 9 percent in 1990, but decreased 6 percent in 2000, the increases being due to greater power plant emissions.

**5182** (TEC—75/006c, pp 65p., Task Report 8) **Resource and environment impacts of electric cars in St. Louis and Philadelphia.** Sjovold, A.R. Sep 1975.

In Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume III. Task reports on impact and usage analyses. Final report.

Several important environmental consequences that would accrue to electric car usage are discussed, including analyses of the impacts on material supplies and demands to produce and use electric cars, power plant thermal waste discharges, generation of radioactive wastes, generation of other solid and liquid wastes, and community noise pollution. The analyses are related to regional electric car implementations in St. Louis and Philadelphia with comments on the implications of a nationwide implementation. The impact analyses span the period from 1980 to 2000, and are parametric in electric car usage with upper bound usage levels of 20 percent in 1980, 80 percent in 1990, and 100 percent in 2000. For very high regional electric car populations, significant additions to total U.S. demands of some materials will occur, depending on the battery technology employed. Critical material demands in this respect are nickel for nickel—zinc batteries, and lithium and graphite for lithium—sulfur batteries. For a large-scale nationwide implementation, critical material demands would arise for lead, antimony, nickel, titanium metal, lithium, and graphite. It is assumed that all of the metals will be highly recycled. Thermal waste discharges (i.e., waste heat) and radioactive wastes are projected to grow, commensurate with the baseline projections for electric power demand. Electric cars should increase slightly the solid and liquid waste problems, but potentially can reduce urban traffic noise.

## ENERGY RESOURCES

*REFER ALSO TO CITATION(S) 5182, 5303, 5304*

**5183** (PB—243318) **Texas energy resources. Final report.** (Texas Governor's Energy Advisory Council, Austin (USA)). Jul 1974. 32p. NTIS $3.75.

It is well known that Texas is the Nation's leading state in developing and sharing its oil and gas resources, and in this report it is pointed out that the State has other large energy resources that are less widely known. These include lignite, coal, geothermal energy and uranium ores. Texas also has the potential for solar, solid waste and wind energy. (GRA)

**5184** **Danger of federal withdrawals to natural resources development (Abstract).** Aspinall, W.N. (Natural Resources Values, Palisade, CO). *Am. Assoc. Pet. Geol. Bull.*; **60**: No. 8, 1389-1390(Aug 1976).

From 25. annual meeting AAPG—SEPM Rocky Mountain Sections; Billings, MT, USA (28 Mar 1976).

The finding, exploration, and development of resources in and on the earth are necessary to modern man's existence. More than one-third of our nation's natural resources belong to the Federal government which is directly responsible for what happens to that third. Currently there is widespread thought in our nation either not to develop our natural resources or to make the development of such natural resources so difficult and complicated that in all too many instances the obstacles and delays to development work against our national welfare. A point at issue is a current practice of our national administrative agencies of government to withdraw (either with or without statutory authority) greater and greater amounts of our federal lands from development. The statutorily authorized, as well as the expressed, national policy of multiple use of our natural resources is being disregarded and voided to the extent of endangering our free-enterprise system and the stability of our government.

## RESEARCH AND DEVELOPMENT

*REFER ALSO TO CITATION(S) 5165, 5192*

**5185** (MIT-EL—76-008) **International diffusion of energy technology. Report of a workshop held on June 2—3, 1976, at Dedham, Massachusetts.** (Massachusetts Inst. of Tech., Cambridge (USA). Energy Lab.). Jul 1976. Contract E(49-18)-2295. 17p. Dep. NTIS $3.50.

The workshop brought together corporate officers, government officials, and academic specialists to discuss problems in the international transfer of energy technology and international cooperation in energy R and D as seen from industry's perspective. This report summarizes the highlights under the following topics: government/industry relations in the international context; industry participation in international R and D cooperation; problems in acquiring foreign technology due to U.S. regulations for information dissemination; ERDA patent policy; export controls; assistance abroad from the U.S. government; the significance of U.S. government regulation; and ERDA's role in the commercialization of energy technology. (MCW)

**5186** **View from ERDA...1976 update.** Seamans, R.C. Jr. (Energy Research and Development Administration, Washington, DC). *Public Util. Fortn.*; **98**: No. 7, 23-24(23 Sep 1976).

ERDA was commissioned to survey the short- and long-range energy problems of the nation and to direct the effort of the public sector to assist in the development of fuels and energy technologies not yet commercially feasible, but promising. The national plan focuses on assisting industry to accelerate seven high-priority technologies or programs. These include: (1) conservation technologies, (2) nuclear fuel cycle programs, (3) enhanced recovery of oil and gas, (4) increased direct use of coal, (5) synthetic fuels programs, (6) expanded use of geothermal energy, and (7) the introduction of solar heating and cooling. These are the technologies and programs at or near commercial application, and the plan aims at promoting their penetration of the market. The plan also identifies strategies for developing three high-priority

programs with longer-term potential: breeder reactors, solar electric, and nuclear fusion. In the short term, efforts to increase recoverable amounts of domestic oil and gas and overcome problems to allow increased use of coal and nuclear power are stressed. In the midterm, from 1985 and beyond, emphasis is placed on processes for producing synthetic fuels from coal and extracting oil from shales. At the same time, research, development, and demonstration strategies are conducted so as to provide some margin for potential failure by broad-based programs rather than banking too heavily on a single energy resource. Finally, the strategy calls for a serious effort to reach for an eventual energy system that depends on inexhaustible or renewable resources. These include solar energies in various forms and nuclear fuels either with fission breeder reactors or with fusion. (MCW)

## NUCLEAR ENERGY

*REFER ALSO TO CITATION(S) 4754, 4929, 4935, 5167, 5201*

**5187 Securing reactor safety objectives in the nuclear power program worldwide.** Hendrie, J.M. (Brookhaven National Lab., Upton, NY). *At. Energy Law J.*; 17: No. 4, 338-359(Win 1976).

Research on reactor safety matters has been carried out on a broad front and for a long time. Properties and behavior of fission products and other materials, component and system performance and failure modes, accident analysis methods and computational techniques, heat transfer and fluid flow phenomena, fracture mechanics and structural analysis methods—these and many more subjects have been studied at length in reactor safety programs in many countries. A substantial number of reactor experiments have been run, some in the form of complete reactor systems and others as scaled portions of reactors to model specific phenomena of interest in accident analysis. All of these activities have resulted in a large body of knowledge about reactor safety. Adding to this knowledge at an increasing rate is the operating experience of nuclear plants in commercial power-producing operations all over the world. The present situation in reactor safety is reviewed, and directions for future improvements are examined. At present there are over 150 nuclear plants in regular commercial operation, with 50-odd of these in the U.S. and about 100 in 18 other nations. A summary of current projections about possible accident consequences and probabilities supplements the operating record and, with a description of the present safety design basis, describes the present status. The discussion on future improvements takes note of the great value to improved safety of a complete and well-developed body of codes and standards for power reactor design, construction, and operation. Surveys of the efforts now in progress to establish such sets of codes and standards complete the discussion. Codes and Standards discussed are The American Standards System and the International Standards and the IAEA Program. (MCW)

**5188 Perspective on worldwide nuclear developments.** Doub, W.O.; Muntzing, L.M. (Atomic Energy Commission, Washington, DC). *At. Energy Law J.*; 17: No. 4, 235-249(Win 1976).

While this article centers on discussing the world need for energy, reviewing some of the problems that are being encountered in meeting that demand, and making some recommendations, the overriding point is that much depends upon America's own internal policies. Most of the nuclear technology-recipient nations are the less-developed countries, and just meeting present needs is forcing them to financial limits in terms of attracting external financing. Meanwhile, the dollar dimensions of "going nuclear" are increasing and the fact that it can take eight to ten years before a nuclear plant begins paying out threatens to take proposals for external financing "off the market." There must be direct government support of nuclear plant proposals in recipient nations. There is a parallel need for institutions—such as the United States' own Export-Import Bank—to come up with policies specifically geared to nuclear needs. Both actions should receive support because building those plants is of national importance, both to the exporter and the recipient. In the view of those involved in such financing, there is no doubt the global money markets can meet the demand, but the allocation process needs tailoring to the specific nuclear situation. The export of nuclear power, in a properly competitive atmosphere that does not encourage reduction of protective features and that effectively controls the risks of nuclear power, is one of the most feasible means by which the U.S. can help mankind toward an improved world society.

**5189 Nuclear cooperation and non-proliferation.** Kratzer, M.R. (Dept. of State, Washington, DC). *At. Energy Law J.*; 17: No. 4, 250-288(Win 1976).

During the years since World War II, few if any areas of vital foreign and national security policy have been the object of such consistency of approach and continuity of effort as has been that of deterring the proliferation of nuclear weapons. The proliferation which has occurred is a matter of grave import. Yet, measured against the diffusion of other new technologies—both civil and military—the acquisition of nuclear explosive capabilities during the 30 years that have passed since the development of the atomic bomb has been encouragingly limited. This is not accidental. It has been, in large measure, the result of U.S. policies and programs and of active U.S. leadership directed toward the containment of national capabilities for the acquisition of nuclear weapons. However, the results do not allow complacency. Concern still exists regarding the growing stockpiles of plutonium and the spread of sensitive technologies such as reprocessing. The results do, nevertheless, give cause for encouragement that proliferation is not inevitable, and that, with the best of effort, it can be contained..

**5190 U.S. congressional attitudes and policies affecting nuclear power development in the world.** McCormack, M. (House of Representatives, Washington, DC). *At. Energy Law J.*; 17: No. 4, 289-321(Win 1976).

The world future for nuclear power is even now being formed by policies and decisions of many governments and international organizations. Congressman McCormack looks to the United States for revived and stronger leadership in strengthening the web of institutions and international relations to permit the world to reap the benefits of nuclear power without a destabilizing spread of nuclear weapons. He says Congress will have a major role in shaping that nuclear future. The tensions between Congress and the executive branch that are part of the U.S. system of separation of powers can help to test and strengthen future policy on international nuclear power. The point of no return along the course of nuclear evolution is approaching and the author asks: will we press on to create an acceptable balance between benefits of nuclear power and the risk that expanded use may increase proliferation—or will we turn back toward nuclear isolationism. Mr. McCormack opts for vigorous legislative, executive and diplomatic initiatives to sustain U.S. nuclear leadership so that we can accelerate and influence world measures to prevent proliferation while developing uranium and thorium as future world energy resources.

**5191 International Atomic Energy Agency (IAEA) and its role in world-wide security of nuclear fuels and facilities and non-proliferation.** Eklund, S. (IAEA, Vienna). *At. Energy Law J.*; 17: No. 4, 322-337(Win 1976).

This article outlines the wide range of the Agency's concerns in both promoting the peaceful uses of nuclear energy and ensuring that it is safely used with minimal risk of damage to man and his environment. This latter aspect includes measures against diversion to military purposes, theft or sabotage. There is a marked tendency to leave the promotion of nuclear energy to industry and commerce, and for many regional and national nuclear energy authorities to become increasingly absorbed in its safety and regulatory aspects—the ultimate aim being the establishment of a world nuclear law. This trend will certainly also be reflected in the Agency's program and will gain strength as time goes on. However, the International Atomic Energy Agency is sharply differentiated from national authorities in the industrial countries and from most regional nuclear energy authorities by the fact that its program must continue to reflect the needs of the developing nations which constitute a majority of its Member States. These nations—most of which are "energy hungry"—need the Agency's help to benefit from the peaceful applications of nuclear science and technology.

**5192 Seamans expects nuclear-waste plan to be in effect 'before this year is out'.** *Energy Res. Rep.*; 2: No. 9, 7-11(Sep 1976).

An interview with Robert C. Seamans, Jr., administrator of the Energy Research and Development Administration, was conducted on July 21 and updated Aug. 5. Dr. Seamans responded about progress on the breeder reactor. He expects a policy to be formulated on the spent fuel coming out of the reactor by the end of 1976. A decision should be made in ten years on the final development of the breeder. He explained that in ten years uranium fuels will be in short supply and will need to be utilized in the most efficient reactor. When questioned, he also supplied answers on delays on bills sent to Congress. Appropriations, conservation policies, consolidation of programs, and manpower needs in ERDA were discussed. The attention ERDA is paying to the synthetic fuels programs and the environment are aired. When asked about technology exchanges with other countries, Dr. Seamans told of a fine relationship with the UK, USSR, and the Germans, but reported a difficult institutional problem with France on licensing. (MCW)

## TRANSPORT AND STORAGE

*REFER ALSO TO CITATION(S) 5172, 5173, 5174, 5175, 5181, 5182, 5233*

**5193** (TEC—75/006b) **Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume II. Task reports on electric car characterization and baseline projections. Final report.** Hamilton, W.F.; Eisenhut, J.C.; Sjovold, A.R. (General Research Corp., Santa Barbara, Calif. (USA)). Sep 1975. Contract E(04-3)-1119. 256p. Dep. NTIS $7.60.

Results are presented of a study of the projected effects of electric vehicles on energy use, the environment, and the economy of the two urban areas. Volume I contains an executive summary and a technical report, Volume II contains five task reports on electric car characteristics and baseline projections, and Volume III contains four task reports on impact analyses. The task reports in Volume II are on (1) characterization of battery-electric cars for future use; (2) population projections from 1980 to 2000; (3) transportation projections from 1980 to 2000; (4) electric energy projections from 1980 to 2000; and (5) economic projections from 1980 to 2000. A separate abstract for each section was prepared for ERDA Research Abstracts (ERA) and for Energy Abstracts for Policy Analysis (EAPA). (PMA)

**5194** (TEC—75/006b, pp 47p., Task Report 3) **Transportation projections for the St. Louis and Philadelphia regions, 1980—2000.** Hamilton, W.F. Sep 1975.

In Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume II. Task reports on electric car characterization and baseline projections. Final report.

Transportation projections are developed for the St. Louis and Philadelphia areas, primarily from existing plans and projections, as a basis for evaluating future impacts of electric cars. Overall indications are that the two regions are growing more alike, so that by 1990 they will be about equally dependent on automobiles. Auto populations in each region are projected to rise about 50 percent by the year 2000, to the level of 1.4 licensed drivers per car in St. Louis and 1.5 in Philadelphia. At the same time, the proportion of small cars (subcompact and compact) is expected to rise from the recent figure of 26 percent to 65 percent by the end of the century. Average auto usage is projected as 10,000 miles per year, near the current figure, but there are many uncertainties involved. Auto fuel economy is projected to rise 50 percent over 1975 by 1984, and 100 percent by the year 2000. As a result, total fuel consumption by autos in the two regions is expected to be somewhat below the current level by 1990.

**5195** (TEC—75/006b, pp 63p., Task Report 4) **Electric energy projections for the St. Louis and Philadelphia regions, 1980—2000.** Sjovold, A.R. Sep 1975.

In Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume II. Task reports on electric car characterization and baseline projections. Final report.

Baseline electric energy projections for the St. Louis and Philadelphia study areas are established covering the period from the present to the year 2000, with the specific purpose of facilitating the study of electric car impacts for these two regions. Projections of peak power demands, annual electric energy consumption, sources of generation, and generation efficiencies and costs are provided. The St. Louis region presently depends to a great extent on coal-fired steam generation, with peak demands served through a combination of hydroelectric, pumped storage, purchased power, and oil-fired steam and combustion turbine facilities. Nuclear generation facilities, introduced by 1985, will account for 87 percent of annual kWh generation by 2000. The present mix of facilities will still be necessary, however, in meeting peak day demands. The Philadelphia region is already served by nuclear power and presently depends nearly equally on nuclear and oil- and coal-fired steam facilities for its annual electric energy production. Peak demands are met through a combination of hydroelectric, pumped storage, and combustion turbine facilities. Nuclear power will provide more than half of total generation by 1985 and 94 percent by the year 2000. However, all the existing facilities in addition to the nuclear will be necessary to meet peak demands in 2000. Costs and efficiency of generation for both study areas are expected to rise. After a rapid initial rise prior to 1980, costs will rise more slowly until 2000 (exclusive of inflation beyond that experienced to date). Overall generation efficiencies for both areas ultimately will be dominated by the capabilities of nuclear generation, reaching 33 percent in St. Louis and 36 to 37 percent in Philadelphia.

**5196** (TEC—75/006c, pp 70p., Task Report 6) **Energy impacts of electric cars in St. Louis and Philadelphia.** Sjovold, A.R. Sep 1975.

In Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume III. Task reports on impact and usage analyses. Final report.

Electric cars are projected to use primary energy more efficiently than the average future internal combustion engine (ICE) car, but less efficiently than subcompact ICE cars with which they are more nearly competitive in size and performance. At high electric car usage levels, electrics would necessarily replace some of the larger, less-efficient ICE cars, and thereby provide some small savings in total primary energy consumption for automotive travel. Projected electric power generation capacity increases will be capable of supplying sufficient off-peak power to recharge a 100 percent electric car population in the year 2000. An approximately 80 percent electric car population in 1990 can be similarly accommodated. Recharge energy for higher levels of electric car use in St. Louis will initially come from coal-fired generation sources in 1980, and shift heavily (67 percent) to nuclear sources by 2000. In Philadelphia, 1980 recharge energy will come solely from oil-fired steam generation plants, and shift heavily (91 percent) to nuclear sources by 2000. These situations compare to that for Los Angeles where 1980 recharge energy comes solely from oil-fired steam, but less than 45 percent will come from nuclear sources in 2000. Consequently, relative savings in regional petroleum consumption are least in Philadelphia and Los Angeles in 1980, but greatest in Philadelphia in 2000. St. Louis offers the greatest relative petroleum savings in 1990, when Philadelphia and Los Angeles are in transition from oil-fired to nuclear generation sources.

## CONSERVATION

*REFER ALSO TO CITATION(S) 4653, 5167, 5234, 5260, 5270*

**5197** (PB—241820) **Federal energy management program, fiscal year 1974. Annual report No. 1.** (Federal Energy Administration, Washington, D.C. (USA). Office of Energy Conservation and Environment). Dec 1974. 60p. (FEA/D—74/194). NTIS $4.25.

Government policies pertaining to energy conservation are reviewed and various agency programs and accomplishments noted. Summary sheets on energy usage by government agencies are included. (GRA)

**5198** (PB—241856) **Federal energy management program, fiscal year 1975. Quarterly report No. 1, Jul—Sep 74.** (Federal Energy Administration, Washington, D.C. (USA). Office of Energy Conservation and Environment). Sep 1974. 10p. (FEA/D—75/283R). NTIS $3.25.

Statistical data on energy conservation performance by various government agencies during first quarter of fiscal year 1975 are presented. (GRA)

**5199** **User documentation for the FHWA Carpool Matching Program (second edition).** Washington, DC; Federal Highway Administration (1975). 56p.

This document provides persons interested in computerized carpool/buspool matching programs a complete description of the user documentation for the FHWA Carpool Matching Program. The FHWA program is written in American National Standard COBOL and thus should be readily transferable to environments other than the IBM 360/65 (OS) under which it has been developed and tested. The program has a compiled time core requirement of 110K and a maximum execution time core requirement of 110K. While considerable effort has been made to test the program in several applications and to achieve accuracy and completeness in the program and supporting documentation, the FHWA cannot guarantee the proper operation of this program by any user nor can it assume liability for any damage, loss, or inconvenience resulting from the operation of this program or the results obtained thereby. This present version of the carpool matching program represents the latest version of the first generation of an ongoing multi-phase process of improvements and refinements. The ultimate goal is an effective carpool and transit information system that will produce individualized information covering not only carpooling opportunities, but also transit routing, scheduling, and other identifying information for the commuter. (MCW)

## SUPPLY, DEMAND, AND FORECASTING

*REFER ALSO TO CITATION(S) 5165, 5186, 5225*

**5200** (BNL—21281) **Combined linear programming and econometric systems analysis of the relation between energy,**

**growth, and the economy.** Behling, D.J. Jr.; Dullien, R. (Brookhaven National Lab., Upton, N.Y. (USA); Data Resources, Inc., Cambridge, Mass. (USA)). 1976. Contract E(30-1)-16. 6p. (CONF-760703—8). Dep. NTIS $3.50.

From Summer computer simulation conference; Washington, District of Columbia, United States of America (USA) (12 Jul 1976).

This paper describes efforts currently in progress to integrate econometric models developed by Ed Hudson and Dale Jorgenson of Data Resources, Inc. (DRI) with energy-oriented linear programming and input-output models developed by Brookhaven National Laboratory (BNL). This model integration effort, supported by the Energy Research and Development Administration, is currently being used to evaluate the long-run economic, energy, and environmental effects of various combinations of government energy policies. These include policies designed to stimulate research, development, and ultimate commercial introduction of new energy supply, conversion, and end use technologies, as well as fiscal policies designed to reduce the demand for energy via energy taxes. In this paper, the major goals and assumptions underlying this joint DRI-BNL effort are first presented. Then the various models used in the integration procedure are summarized along with the linkage equations and data transfers which connect them. Next, procedures for solving and/or simulating the combined system are discussed. Finally, some of the advantages and pitfalls of incorporating detailed "classical" activity models with econometrically estimated "neoclassical" general equilibrium models are discussed.

**5201** (BNL—50532) **1985 technical coefficients for inputs to energy technologies.** Lukachinski, J.; Tessmer, R.G. Jr. (Brookhaven National Lab., Upton, N.Y. (USA)). Jun 1976. Contract E(30-1)-16. 38p. Dep. NTIS $4.00.

This report describes the incorporation of input—output technical coefficients for five new energy supply and conversion technologies as estimated by the MITRE Corporation into a 110-sector Energy I—O Model. The five new technologies are solvent refining of coal, oil shale mining and retorting, high-temperature gas-cooled reactor electricity generation, high-BTU coal gasification, and COGAS combined-cycle electricity generation. Incorporation of seven existing energy supply and conversion technologies is also described: crude oil and gas extraction, coal mining, refined petroleum products, pipeline gas, fossil electric generation, and hydroelectric generation. Non-energy input coefficients are given in units of 1967 $/10$^6$ BTU and represent the inputs in constant 1967 dollars from non-energy sectors (e.g. manufacturing, transportation, services) required per $10^6$ BTU of energy production by each of these energy supply technologies. The 90 non-energy sectors included are based on the Bureau of Economic Analysis 83 sector input—output structure for 1967 with minor disaggregations. Energy input coefficients are given in units of BTU/BTU.

**5202** (JUL-Conf—15) **Conference on energy models for the Federal Republic of Germany, Juelich, Germany, January 30—31, 1975.** (Kernforschungsanlage Juelich G.m.b.H. (Germany, F.R.)). Apr 1975. 272p. (In German and English). (CONF-750139—). Dep. NTIS (US Sales Only) $7.60.

From Conference on Energy Models for the Federal Republic of Germany; Julich, F.R. Germany (30 Jan 1975).

In order to guarantee sufficient energy supplies for the future, energy planners involved in both government and economic affairs have to deal with the problem of estimating the consequences of new technologies on the change of the energy-political situation. The aims of this workshop were to show the actual situation of the development of energy models for the whole energy system of the FRG; to formulate the requirements of energy models from the point of view of energy planners in government and industry; to promote the exchange of experiences among the individual groups that deal with the preparation of energy models; and to discuss methods problems. The main conclusion of the research, industry, and economics specialists was that, with the aid of energy models, quantitative statements about the system of energy economy are possible and become more and more significant as aids for planning and decision making in economy and government. (MCW)

**5203** **Energy modeling and forecasting at the Federal Energy Administration.** Walton, H.L. (Federal Energy Administration, Washington, DC). *Trans. Am. Nucl. Soc.*; **23**: 186-187(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5204** **Energy modeling and forecasting program at ERDA.** Williamson, R.H.; Hanrahan, E.J. (Energy Research and Development Administration, Washington, DC). *Trans. Am. Nucl. Soc.*; **23**: 187(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5205** **National electrical forecasting model.** Palmer, R.; Osborne, T.C. (General Electric Co., Sunnyvale, CA). *Trans. Am. Nucl. Soc.*; **23**: 189(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5206** **Energy and electricity forecasting by the UKAEA.** Brookes, L.G. (UKAEA, Winfrith, Eng.). *Trans. Am. Nucl. Soc.*; **23**: 190(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5207** **How well will we meet our energy needs in year 2000.** Starr, C. (Electric Power Research Inst., Palo Alto, CA). *Public Util. Fortn.*; **98**: No. 7, 25-30(23 Sep 1976).

The food crisis of the early 1920s is discussed as a parallel to the present energy crisis. The food crisis was solved in large part by foresight, technological drive, and a national recognition of the need to act. Everyone recognized the need for food, but the author is not sure that everyone recognizes the energy crisis. Dr. Starr sees the answer to the energy crisis as being determined by decisions made in three critical areas: goal targeting, resource management, and timing. He discusses these three areas and then outlines some alternative approaches and suggests a mixture most likely to yield success. Dr. Starr states that our fuel sources will have to change in order to meet our needs, and that the prudent choice is to rely on native coal and uranium for conversion to electricity. Accompanying this fuel switch and the resultant growth of the electric fraction will be a vigorous campaign to boost efficiency in energy use. Such conservation technology is as important as supply technology. Meeting a target of 7,500 billion kWh in 2000 will require almost four times the present electricity supply, at a growth rate of about 5.7 per cent per year. And this target assumes reasonable conservation measures. If such measures fail, then a supply more in the neighborhood of 9,000 to 10,000 billion kWh will be needed. (MCW)

## POLICY, LEGISLATION, AND REGULATION

*REFER ALSO TO CITATION(S) 4469, 4470, 4743, 4929, 5166, 5188, 5189, 5190, 5191, 5197, 5198, 5270, 5271, 5682, 5683*

**5208** (PB—241796) **Implementation plan review for Arizona as required by the Energy Supply and Environmental Coordination Act. Final report.** (TRW/Environmental Services, Vienna, Va. (USA)). Dec 1974. Contract EPA-68-02-1385. 49p. NTIS $3.75.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section IV of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5209** (PB—241797) **Implementation plan review for Kansas required by the Energy Supply and Environmental Coordination Act. Final report.** (TRW/Environmental Services, Vienna, Va. (USA)). Dec 1974. Contract EPA-68-02-1385. 76p. NTIS $4.75.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5210** (PB—241930) **Implementation plan review for Arkansas as required by the Energy Supply and Environmental Coordination Act.** (TRW/Environmental Services, Redondo Beach, Calif. (USA)). Apr 1975. Contract EPA-68-02-1385. 70p. NTIS $4.25.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5211** (PB—241931) **Implementation plan review for Texas as required by the Energy Supply and Environmental Coordination Act.** (TRW/Environmental Services, Redondo Beach, Calif. (USA)). Apr 1975. Contract EPA-68-02-1385. 85p. NTIS $4.75.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5212** (PB—241933) **Implementation plan review for Alabama as required by the Energy Supply and Environmental Coordination Act.** (Environmental Protection Agency, Research Triangle Park, N.C. (USA). Office of Air Quality Planning and Standards). Apr 1975. 23p. (EPA—450/3-75-043). NTIS $3.25.

Prepared in cooperation with Argonne National Lab., Ill.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5213** (PB—241934) **Implementation plan review for New York as required by the Energy Supply and Environmental Coordination Act.** (TRW/Environmental Services, Vienna, Va. (USA)). Apr 1975. Contract EPA-68-02-1385. 55p. NTIS $4.25.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5214** (PB—241935) **Implementation plan review for California as required by the Energy Supply and Environmental Coordination Act.** (TRW/Environmental Services, Redondo Beach, Calif. (USA)). Apr 1975. Contract EPA-68-02-1385. 8p. NTIS $3.25.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report of the State indicating where regulations might be revised. (GRA)

**5215** (PB—242017) **Implementation plan review for Georgia as required by the Energy Supply and Environmental Coordination Act.** (Environmental Protection Agency, Research Triangle Park, N.C. (USA). Office of Air Quality Planning and Standards). Apr 1975. 24p. (EPA—450/3-75-042). NTIS $3.25.

Prepared in cooperation with Argonne National Lab., Ill.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5216** (PB—242022) **Implementation plan review for Tennessee as required by the Energy Supply and Environmental Coordination Act.** (Environmental Protection Agency, Research Triangle Park, N.C. (USA). Office of Air Quality Planning and Standards). Apr 1975. 23p. (EPA—450/3-75-041). NTIS $3.25.

Prepared in cooperation with Argonne National Lab., Ill.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of the ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5217** (PB—242132) **Implementation plan review for Vermont as required by the Energy Supply and Environmental Coordination Act. Final report.** (TRW/Environmental Services, Vienna, Va. (USA)). Apr 1975. Contract EPA-68-02-1385. 38p. NTIS $3.75.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisons can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5218** (PB—242135) **Implementation plan review for Connecticut as required by the Energy Supply and Environmental Coordination Act. Final report.** (TRW/Environmental Services, Vienna, Va. (USA)). Apr 1975. Contract EPA-68-02-1385. 56p. NTIS $4.25.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5219** (PB—242306) **Implementation plan review for Montana as required by the Energy Supply and Environmental Coordination Act.** (TRW/Environmental Services, Vienna, Va. (USA)). Mar 1975. Contract EPA-68-02-1385. 51p. NTIS $4.25.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the state indicating where regulations might be revised. (GRA)

**5220** (PB—242307) **Implementation plan review for Wyoming as required by the Energy Supply and Environmental Coordination Act.** (TRW/Environmental Services, Vienna, Va. (USA)). Mar 1975. Contract EPA-68-02-1385. 33p. NTIS $3.75.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5221** (PB—242308) **Implementation plan review for Delaware as required by the Energy Supply and Environmental Coordination Act.** (TRW/Environmental Services, Vienna, Va. (USA)). Mar 1975. Contract EPA-68-02-1385. 39p. NTIS $3.75.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5222** (PB—242537) **Implementation plan review for Indiana as required by the Energy Supply and Environmental Coordination Act. Final report.** (Environmental Protection Agency, Research Triangle Park, N.C. (USA). Office of Air Quality Planning and Standards; Environmental Protection Agency, Chicago, Ill. (USA). Region V; Argonne National Lab., Ill. (USA)). Dec 1974. 69p. (EPA—450/3-74-066). NTIS $4.25.

Prepared in cooperation with Environmental Protection Agency, Chicago, Ill. Region V, and Argonne National Lab., Ill. Energy and Environmental Systems Div.

Section 4 of the Energy Supply and Environmental Coordination Act of 1974, (ESECA) requires EPA to review each State Implementation Plan (SIP) to determine if revisions can be made to control regulations for stationary fuel combustion sources without interfering with the attainment and maintenance of the national ambient air quality standards. This document, which is also required by Section 4 of ESECA, is EPA's report to the State indicating where regulations might be revised. (GRA)

**5223** **Can the private gas utility survive.** Roseman, H.G. (National Econ. Research Association Inc., Washington, DC). *Am. Gas Assoc., Oper. Sect., Proc.;* T4-T7(1975).

Pros and cons of government take-over are discussed.

**5224** **Connecticut conference on energy. Proceedings of a conference held December 11, 1975, in Hartford, Connecticut.** East

Hartford, CT; Connecticut Air Conservation Committee (1975). 72p. Connecticut Air Conservation Committee, 45 Ash St., E. Hartford, CT 06108.

The question at issue was: do economic and environmental health goals need to conflict in the development of energy policy. Governor Ella Grasso in the opening address and commissioner Lynn Alan Brooks of the Connecticut State Department underlined the State's role in conservation efforts designed to save energy and money for the citizens of Connecticut. Dr. William Marcuse recommended state legislation to promote a decrease in energy consumption, asserting that this is preferable to expansion of energy supply both in terms of environmental and economic effects. Mr. Kenneth Johnson and Dr. Leonard D. Hamilton pointed specifically to the Northeast region in discussing the serious environmental and health impacts of current energy policies, and suggested that environmental contaminants resulting largely from waste products of fossil-fuel combustion should be minimized through technological and regulatory actions. Finally, Mr. Monte Canfield's summary presentation on future alternative energy policies showed that an energy scenario that cuts in half our current energy consumption growth rate (3.5 percent to 1.6 percent) would result in a $300 billion savings over twenty-five years in capital costs for energy in the United States. Energy conservation, then, was considered to be the most important component of energy policies designed to protect health, environment, and economy. The conclusions and recommendations of the speakers and participants in the conference strengthened the resolve of the Connecticut Air Conservation Committee to work constructively for clean air, while stressing energy conservation in its public education efforts. Stephen B. Soumerai was program manager of the conference. (MCW)

**5225 U.S. international energy policy: October 1973—November 1975.** Washington, DC; Department of State (1975). 47p.

The oil embargo in October 1973 followed by price increases of 400 percent in less than a single year—largely the result of political decisions—created an immediate economic crisis, both in the U.S. and around the world. The elements of the energy problem, however, had been developing over the past 20 years: in 1950, the U.S. was virtually self-sufficient in oil, whereas by 1973 our reliance on foreign oil had reached 35 percent of our requirements. The experience of the embargo and the subsequent massive price rise showed the U.S. how vulnerable it had become. The crisis focused attention dramatically on the reality of increasing global interdependence, demanding a cooperative response among the oil-consuming countries and ultimately between consumers and producers. In December 1973 Secretary of State Kissinger called for collective action by the nations of Europe, North America, and Japan to meet the challenge. The outcome was the establishment of the 18-nation International Energy Agency (IEA) in Paris in November 1974. The IEA has made remarkable progress in forging consumer solidarity and in paving the way for a meaningful dialogue with the producer nations. This dialogue hopefully will result in a cooperative long-term relationship between consumers and producers. The course of U.S. international energy policy from the October 1973 embargo to the current preparation for a Conference on International Economic Cooperation can be traced by certain benchmark documents assembled in this publication. Taken together, they provide a comprehensive picture of America's efforts and determination to meet the challenge of the energy crisis through a policy of cooperation and conciliation. (from Introduction)

## FOSSIL FUELS

*REFER ALSO TO CITATION(S) 5201*

### COAL

*REFER ALSO TO CITATION(S) 4367, 4370, 4398, 4410, 4415, 4421, 4423, 4425, 4427, 4430, 4441, 4442*

**5226 Chemicals from coal.** Squires, A.M. (City Coll., New York). *Science;* **191**: No. 4228, 689-700(20 Feb 1976).

Only those persons very well versed in methods of technological change realize how short the time is that remains before the world must make a major shift from oil to coal for its industrial energy needs. The return to coal must provide for clean combustion and conversion to clean industrial fuels. The quickest way to capture significant supplies of new gas and oil is to convert existing boilers and furnaces to burn clean fuels from coal. The following processes that could be realized the soonest are discussed: gasification with steam and oxygen; partial conversion of coal; flash pyrolysis; partial gasification by steam; flash hydrogenation; supercritical gas extraction; chemicals from coal tar; and coal liquefaction. Work has been in progress for many years on rapid pyrolysis of coal in a plasma arc at temperatures beyond 1400°C to make acetylene. It is believed the process has the potential of making acetylene competitive with ethylene, but acetylene can only substitute for ethylene in about 17 percent of its uses. 47 references. (MCW)

**5227 (NSF-RA-N—75-037I) Critique and response to "Coal transportation". A portion of the Coal Future: Economic and Technological Analyses of Initiatives and Innovations to Secure Fuel Supply Independence.** (National Science Foundation, Washington, D.C. (USA)). 1975. 22p. (NSF—76-13). Dep. NTIS $3.50.

In May 1975 the final report of a study titled. "The Coal Future: Economic and Technological Analysis of Initiatives and Innovations to Secure Fuel Supply Independence" (see EAPA 2:574) was released to the public. This study examined numerous potential problems that could prevent the expanded use of coal. The chapter titled "Coal Transportation" addressed a subject being debated in both the public and private sectors of the Nation. Subsequent to release of the final Coal Future Study, the National Science Foundation received a critique of the Coal Transportation (IV) section. The critique had been prepared by L.E. Peabody and Associates, Inc. for Energy Transportation Systems, Inc. The University of Illinois research team (who made the study) was asked to examine the L.E. Peabody and Associates critique, and to provide their response. This report contains both the L.E. Peabody and Associates, Inc. critique and the University of Illinois response. The issue of alternative models of coal transportation is of continuing major public and private interest. Therefore, public dissemination of opposing perspectives on the coal transportation issue should provide the research community and the public with an opportunity to arrive at their own conclusions. It is hoped that open examination and debate of these issues of national importance will lead to resolution of the differences and ultimately provide a better basis for setting long-term energy policies in the national interest.

### PETROLEUM

*REFER ALSO TO CITATION(S) 4419, 4446*

**5228 (COM—75-10772) Coastal Plains deepwater terminal study. Volume I. Executive summary study report.** (Nathan (Robert R.) Associates, Inc., Washington, D.C. (USA); Coastal Zone Resources Corp., Wilmington, N.C. (USA)). Jan 1975. 344p. NTIS $9.50.

Prepared in cooperation with Coastal Zone Resources Corp., Wilmington, N.C. Sponsored in part by Coastal Plains Regional Commission, Washington, D.C. Executive summary separately inserted. See also Volume II, COM—75-10773.

The report examines factors affecting feasibility of locating refineries, petrochemicals and auxiliary deepwater terminals in the Coastal Plains Region of North Carolina, South Carolina and Georgia and identifies siting criteria. Analysis of economic and environmental factors is the primary objective of this analysis. Analysis includes investment facilities description, economic impact analysis, public revenue and expenditure implications, and environmental analysis. (GRA)

**5229 (COM—75-10773) Coastal Plains deepwater terminal study. Volume II. Technical appendixes.** (Nathan (Robert R.) Associates, Inc., Washington, D.C. (USA); Coastal Zone Resources Corp., Wilmington, N.C. (USA)). Jan 1975. 320p. NTIS $9.25.

Prepared in cooperation with Coastal Zone Resources Corp., Wilmington, N.C. Sponsored in part by Coastal Plains Regional Commission, Washington, D.C. See also Volume I, COM—75-10772.

For abstract, see abstract for Vol. I, COM-75-10772.

### NATURAL GAS

*REFER ALSO TO CITATION(S) 4653, 5223*

## HYDROGEN AND SYNTHETIC FUELS

*REFER ALSO TO CITATION(S) 4634*

## ELECTRIC POWER

*REFER ALSO TO CITATION(S) 4743, 5195, 5196, 5201, 5207*

**5230** (PB—242718) **Coordination, competition, and regulation in the electric utility industry.** Penn, V.W.; Delaney, J.B.; Honeycutt, T.C. (Nuclear Regulatory Commission, Washington, D.C. (USA)). Jun 1975. 55p. (NUREG—75/061). NTIS $4.25.

An investigation of the interrelated roles played by competition, coordinaton and regulation in the electric utility industry has been prepared by the Office of Antitrust and Indemnity of the Nuclear Regulatory Commission. The effect of coordinated planning and facilities on competition is contrasted with the effect on competition of the holding company or other forms of industry consolidation. Finally, the role of regulation, as it affects both coordination and competition, is discussed. The authors conclude that competition and coordination in the electric utility industry are compatible with one another, and that regulation should be aimed at encouraging opportunities for both. (GRA)

**5231** **Review of power planning in the Pacific Northwest. Calendar year 1975.** Vancouver, WA; Pacific Northwest River Basins Commission (1976). 120p. Information Dept., Pacific Northwest River Basins Commission, P.O. Box 908, Vancouver, WA 98660.

Chapter I discusses the significant power planning related events, activities, studies, and reports that occurred or were issued during the year. One such event was the introduction of nuclear power plant moratorium bills by the various states. The organization of ERDA, the Hydro-Thermal Power Program, and the state thermal power plant site evaluation activities are discussed. Chapter II presents load estimates through the year 2020. Chapters III and IV review the resources existing, under construction, and feasible for development in meeting the forecasted loads. Chapter V gives a review of some of the research and development activities under way in the electric power field. Chapter VI, "Comparison of Loads and Resources", gives the overall picture of the power situation in the Pacific Northwest. Current generation installation schedules indicate the addition of about 11,600 MW of peak capability during the next 6 years, consisting of 7,400 MW of additional hydro resources and 4,200 MW of new thermal resources. These installations will produce about 4,100 MW of additional energy, of which about 200 MW will come from hydro and 3,900 MW from thermal. If slippages occur and if poor water conditions are experienced, the Pacific Northwest will face a severe shortage of electric energy during the next several years. Some of the environmental problems related to power are examined in Chapter VII. These include the passage of fish over dams, management of nuclear wastes, and the environmental impact statement for a coal-fired plant. Chapter VIII discusses the activities of the Power Planning Committee during the year. Chapter IX is a bibliography of recent publications that affect planning for power in the region. A map titled "Electric Power Plants in the Pacific Northwest and Adjacent Areas" is included. (from Introduction)

## CONSUMPTION AND UTILIZATION

*REFER ALSO TO CITATION(S) 5193, 5261*

**5232** (ORNL/TM—5470) **Engineering-economic model of residential energy use.** Hirst, E.; Lin, W.; Cope, J. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 57p. Dep. NTIS $4.50.

This report describes a comprehensive engineering-economic computer model used to simulate energy use in the residential sector from 1970 to 2000. The purpose of the model is to provide an analytical tool with which to evaluate a variety of conservation policies, technologies, and strategies for their impacts on residential energy use and fuel expenditures over time. The present version of the model deals with energy use at the national level for four fuels (electricity, gas, oil, and other); six end uses (space heating, water heating, refrigeration, cooking, air conditioning, and other); and three housing types (single-family units, apartments, and trailers). Each of these fuel uses is determined for each year of the simulation as the product of: stock of occupied housing units, fraction of homes using each fuel for each end use, average annual energy requirement for each type of equipment, average thermal integrity for each housing type, and household usage behavior for each fuel and end use. Simulations of energy use from 1960 to 1974 show that the model does an excellent job of forecasting historical fuel use data in aggregate, by fuel, and by end use. The baseline forecast shows total fuel use growing from 17.6 GGJ ($10^{18}$ J) in 1975 to 26.4 GGJ in 2000, with an average annual growth rate of 1.7 percent. The percentage of household fuel provided by electricity grows from 44 percent in 1975 to 56 percent in 2000. The percentages provided by all other fuels decline over time. Alternative high and low forecasts show a range in annual fuel use growth from 1975 to 2000 of 2.1 to 0.3 percent. In the high case, per household fuel use grows at 0.4 percent/year, whereas in the low case, per household fuel use declines 1.1 percent/year.

**5233** (TEC—75/006b, pp 44p, Task Report 1) **Characterization of battery-electric cars for future use in the St. Louis and Philadelphia regions.** Hamilton, W.F. Sep 1975.

In Impact of future use of electric cars in the St. Louis and Philadelphia regions. Volume II. Task reports on electric car characterization and baseline projections. Final report.

Electric cars for future use in St. Louis and Philadelphia are characterized to support subsequent analysis of their potential impacts. Like cars characterized previously for a study of impacts in the Los Angeles area, these cars are low-performance subcompacts weighing from 2200 to 3500 pounds; they can carry up to 4 passengers at freeway speeds, and offer urban driving ranges of 54 to 140 miles. In Philadelphia and St. Louis, where climatic conditions are much less moderate than in Los Angeles, average annual energy consumption of electric cars will be increased up to 10 percent by demands for heating and air conditioning, with consequent range losses which will moderately reduce applicability of the electric cars to daily driving patterns. A conventional subcompact with performance as low as the nearer-term electric car is also considered; its fuel economy, about 27 percent higher than that of the average subcompact, affords an appropriate basis for comparisons of energy consumption of electric and conventional cars.

**5234** **Energy and freight movements.** French, A. (Dept. of Transportation, Washington, DC). *Transport. J.*; **16**: No. 1, 26-41(Fal 1976).

This paper was presented to the Transportation Research Board, Washington, D.C., January 1976.

It has been suggested that freight be shifted from truck to rail or barge because the national average ton-miles per gallon or ton-miles per Btu are higher for the nonhighway modes. There is also considerable concern that up to half the travel by some trucks, rail cars, and barges takes place with the vehicle empty. Consideration of typical situations and conditions of operation reveal that alternatives to apparently inefficient situations may actually require additional petroleum to accomplish a given transportation task. Highway transportation at 18.4 percent of all energy accounts for 40.4 percent of petroleum consumption. Trucks, with 5.4 percent of the total, account for 21.6 percent of transportation energy and 29.4 percent of highway petroleum. A 10-percent saving here would about equal the potential saving from the 55 mph speed limit. Four examples for intercity operation and two examples more typical of urban operation are described. (MCW)

## UNCONVENTIONAL SOURCES AND POWER GENERATION

**5235** **ERDA and the advanced power conversion program.** Crim, W.M. Jr. (Office of Coal Research, Washington, DC). *Mech. Eng.*; **98**: No. 5, 24-25(May 1976).

The mission of the U.S. Energy Research and Development Administration is to develop all energy sources, to make the nation basically self-sufficient in energy, and to protect public health and welfare and the environment. ERDA programs are divided into six major categories: conservation of energy; fossil energy; solar, geothermal, and advanced energy systems; environment and safety; nuclear energy; and national security. The goal of the Advanced Power Systems Program is to develop technology for the demonstration of clean, efficient, reliable, economically feasible methods of converting coal and coal-derived fuels to electrical energy in commercial-size central station power plants at the earliest practical date. Advanced Power Conversion technology programs have been developed in the following areas: (1) open-cycle high performance gas turbine/combined cycle; (2) closed power systems—closed-cycle gas turbine and alkali metal vapor turbine; and (3) advanced support technologies—system studies and evaluation; bearings, seals, rotors, etc.; materials, erosion, corrosion, fireside; instrumentation, controls. (MCW)

### SOLAR

*REFER ALSO TO CITATION(S) 4674*

**5236** **Survey of solar buildings.** Gray, R.; Baker, S. Eugene, OR; Center for Environmental Research (1976). vp. Center for Environmental Research, School of Architecture and Allied Arts, Univ. of Oregon, Eugene, OR 97403.

The purpose of this survey is to bring together information concerning the growing numbers of buildings utilizing solar energy.

The survey is designed to facilitate the comparison of specific information about the buildings. Each building has a separate entry which first lists in a standard form the detailed information, after which comments, a bibliography, and a drawing follow. The buildings are arranged by state or foreign country, and roughly by date within each state. It is intended that the survey be regularly updated as more solar buildings are designed and operated. There are 14 solar buildings described in the northeast region of the U.S.; 9 in the southeast region; 8 in the midwest region; 25 in the southwest region; 10 in the northwest region; and 7 in the other countries. (MCW)

**5237 Ocean energy: floating factories could harvest 40 percent of nation's ammonia needs.** *Commer. Am.;* 1: No. 20, 4-5(27 Sep 1976).

A study conducted by the Maritime Administration, Department of Commerce, entitled Maritime and Construction Aspects of Ocean Thermal Energy Conversion (OTEC) Plant Ships, studied the feasibility of building vessels to convert ocean thermal energy into electricity and to produce ammonia, hydrogen, aluminum, and other energy-intensive products at competitive costs. By 1986 a fleet of 21 specialized commercial vessels could be producing as much as 40 percent of the national ammonia requirements out of energy derived from the oceans, at a considerable saving in natural gas which now is the principal raw material used in making ammonia. The report proposes that each of these vessels could produce 1,600 tons of ammonia/day, by "grazing around" at speeds below one knot in the tropical seas, where the temperature differential between surface waters and the depths is highest. The capital cost of such vessels varies inversely to the temperature differential of the available water, so the tropical location could reduce costs by a factor of as much as 2.5 from a site located near the U.S. coast. The OTEC vessels would produce electricity by piping aboard warm surface water to evaporate ammonia in a closed system, creating a vapor which would drive turbine electrical generators. The vapor would then be condensed by cold water drawn from depths of 2,500 feet, and the cycle would begin again. The electricity generated by this process would be used to electrolyze water to produce hydrogen and to power an air liquefaction plant to produce nitrogen. The hydrogen and nitrogen would then be compressed together to form ammonia. The ammonia would be stored at -28°F until it could be loaded aboard ammonia tankers. (MCW)

### GEOTHERMAL

*REFER ALSO TO CITATION(S) 4723*

### OTHER

**5238 Not out of the woods.** Calef, C.E. (Brookhaven National Lab., NY). *Environment;* 18: No. 7, 17-20, 25(Sep 1976).

During the energy crisis of the winter of 1973, state and national forests were opened to individuals wishing to cut firewood; state forests in New York are still open for such purposes upon payment of a small fee. And woodburning stoves are enjoying a comeback. The idea of returning to large-scale burning of wood products for energy might at first seem retrogressive, but proponents point to its many attractive features: it is a solar technology, depending only upon the inexhaustible radiant energy from the sun; unlike most other solar technologies, it is proven; the energy source of the technology—the growing plant—does not require large quantities of exotic, rare, and sometimes toxic materials as do more sophisticated man-made solar-conversion contrivances; and green plants obviously are self-replenishing and biodegradable and when plants are burned they produce relatively little air pollution. The shortcomings of the technology are then summarized. Minimal resource requirements for growth of different plant communities are calculated for two situations: (1) the resulting biomass would supply all U.S. energy requirements; and (2) the biomass would be used to fuel a single 1,000-MW electric plant. The analysis shows that to supply resources for the first situation would be impossible; all the natural plant productivity of the entire country, that is, from all the plants covering the entire land surface, would somehow have to be harvested each year; or, as an alternative, at least 6 percent of the U.S. land surface would have to be turned into intensive energy plantations, all featuring one type of plant. Irrigation water and fertilizer requirements would also be unreasonable. The resource requirements of a biomass-burning 1,000-MW plant would require 4,560 square miles of forests or 230 square miles of intensely grown and harvested sugar cane. (MCW)

# ENERGY CONVERSION

*REFER ALSO TO CITATION(S) 5235*

## MHD GENERATORS

### PERFORMANCE AND TESTING

**5239 Effect of nonuniform conductivity in the boundary layer at the electrode wall on local characteristics of an MHD generator with a diagonal electrode configuration and a subsonic stream.** Kirillov, V.V.; Panovko, M.Y.; Sokolov, Y.N. (High-Temperature Institute, Academy of Sciences, USSR). *High Temp. (USSR) (Engl. Transl.);* 14: No. 1, 157-166(Jan 1976).

A method for calculating the performance characteristics of an MHD generator with diagonal connection of the electrodes is discussed and the results are presented. The method allows for nonuniform conductivity in the boundary layers at the electrode wall, nonideal insulators, and possible intrusion of the electrodes into the flow. The range of governing parameters is the following: relative temperature of the electrode wall T-bar/sub w/=$T/T_e$=0.5-1.0, relative thickness of the boundary layer delta-bar=$2\delta/y_e$=0.1-0.3, degree of electrode intrusion into the flow l-bar=$l/\delta$=0-1.0, Hall parameter $\beta$=0—10. The effect of these parameters on the power, the load coefficient, the angle of electrode connection, and the current and potential distribution in the plasma is shown. (AIP)

### MATERIALS, COMPONENTS, AND AUXILIARIES

*REFER ALSO TO CITATION(S) 5533*

### DUCT ENGINEERING AND FLUID DYNAMICS

**5240 Study of the ionization of the additive in MHD installations.** Pinkhasik, M.S.; Zakharko, Y.A.; Cherkas, V.D.; Nabatov, G.V. (High-Temperature Institute, Academy of Sciences of the USSR). *High Temp. (USSR) (Engl. Transl.);* 14: No. 1, 167-173(Jan 1976).

The time-varying processes underlying the behavior of a drop of aqueous $K_2CO_3$ solution in the circuit of an MHD generator and their influence on the conductivity of the system are considered. Some experimental data relating to the evaporation of water from a 50% aqueous solution of $K_2CO_3$ in drop form are presented. The evaporation of a $K_2CO_3$ melt is considered with due allowance for chemical reactions taking place in the boundary layer. Computed relationships are obtained for the relative conductivity of the combustion products in relation to the time spent by the additive in the gas and air tract of Installation U-25, due allowance being made for the spread of additive particle size. The possibilities of achieving thermodynamic equilibrium of the additive in the combustion products and increasing the plasma conductivity are discussed. (AIP)

## THERMOELECTRIC GENERATORS

*REFER ALSO TO CITATION(S) 4624*

### DESIGN AND DEVELOPMENT

*REFER ALSO TO CITATION(S) 4623*

**5241 Thermoelectric device.** Zeeck, R. (to Allmaenna Svenska Elektriska AB). German(FRG) Patent 2,222,625/C/. 5 Jun 1975. 5p. (In German).

4 figs.

The invention concerns a thermoelectric device with several semiconductor legs and several heat exchangers alternately arranged in series in a stack with a heat-absorbing and a heat-emitting side. They are arranged in such a way that the cooling fins of all heat exchangers have the same direction - at right angle to the stack axis - on the heat-absorbing as well as on the heat-emitting side, that the direction of the cooling fins on the heat-emitting side is opposite to the direction of the cooling fins on the heat-absorbing side, and that each semiconductor leg is in electrical and thermal contact with the neighbouring heat exchangers. The invention provides pressure-generating elements whose compressive force acting on the ends of the stack compresses the stack, and two electrically and thermally insulating supports running along the stack in the longitudinal direction. These are designed in such a way as to determine the position of the heat-absorbing and heat-emitting heat exchangers relative to each other.

**5242 Thermogenerator.** Oesterhelt, G.; Winkler, J.; Falkenberg, D. (to to Siemens AG). German(FRG) Patent 1,932,927/C/. 24 Jul 1975. 6p. (In German).
2 figs.

The invention is based on the task of making a thermogenerator with thermoelements built up as part cascade in which the thermal expansion forces which occur in the longitudinal axis of the limb and in the contact points of the segments of a cascade stage are compensated for with simple means.

### MATERIALS, COMPONENTS, AND AUXILIARIES

*REFER ALSO TO CITATION(S) 5241*

**5243 Thermoelectric materials for devices.** Goff, J.F.; Lowney, J.R. (Naval Surface Weapons Center, Silver Spring, MD). *Trans. Am. Nucl. Soc.*; **23**: 121(Jun 1976).
From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## THERMIONIC CONVERTERS

### MATERIALS, COMPONENTS, AND AUXILIARIES

**5244 Effect of collector material on the characteristics of a thermionic converter.** Gverdtsiteli, I.G.; Korobova, I.L.; Kucherov, R.Y.; Moizhes, B.Y.; Tsakadze, L.M.; Tskhakaya, V.K. *Sov. Phys. - Tech. Phys.* (*Engl. Transl.*); **21**: No. 3, 312-316(Mar 1976).

A comparison is made of the voltage-current characteristics of thermionic converters with Mo[110] emitters and various collector materials: Mo[110] and Nb[110] single crystals, polycrystalline Mo and Nb, and an Mo alloy with Zr and Ti. In addition to a shift of the characteristics along the voltage axis, there is a change in slope. The slope increases with polycrystalline and alloy collectors. The possibility that the deformation of the characteristics is due to an inhomogeneous work function of the collector is checked by calculations on the basis of a mathematical model for a thermionic converter. It is found that in the arc-quenching region and in the diffusion regime the effective collector work function approaches the maximum work function of the patches; in the well-developed arc the effective work function approaches the minimum value. (AIP)

## FUEL CELLS

### DESIGN AND DEVELOPMENT

**5245 Electrochemical cell for the storage of electrical energy.** Dittmann, H.; Schulte, R.W. (to Varta A.G., Frankfurt am Main). German(FRG) Patent 1,596,230. 28 May 1975. 6p. (In German).
2 figs.

The invention deals with an electrochemical cell to store electric energy by water electrolysis, storage and finally recombination of the electrolysis gases obtaining electrical energy with a value electrode for the separation and solvation of hydrogen, an electrode for the separation of oxygen and a gas diffusion electrode for the separation of oxygen and a gas diffusion electrode for the solvation of oxygen, as well as a storage battery made of electrochemical cells of this type.

**5246 Galvanic fuel cell battery.** Lindstroem, O. (to Allmaenna Svenska Elektriska AB). German(FRG) Patent 1,671,696/C/. 12 Jun 1975. 10p. (In German).
13 figs.

Even fuel elements or components of fuel elements which are piled on top of each other to make fuel cell batteries, are generally supplied together with the operational gases and all possess a common electrolyte and coolant flow. The inflow and outflow takes place via holes in the framework of the components. When these are piled on top of one another, channels are formed which involve sealing problems. The invention tries to avoid these difficulties by suitable construction and preparation of the frames.

**5247 Method for the separation of reaction water from fuel elements or fuel batteries and water removal cell for carrying out this method.** Gutbier, H. (to Siemens AG). German(FRG) Patent 1,671,879/C/. 19 Feb 1976. 4p. (In German).
1 fig.

The object of the invention is to considerably improve the method of extracting reaction water from circulating electrolytes of hydrogen fuel cells in order to guarantee a greater operational safety and a lower energy expenditure. The elctrolyte is led through a water-separating cell and brought there into contact with one side of a diaphragm. The steam transported through the diaphragm is condensed. According to the invention the improvement is achieved by compensating the hydrostatic pressure of the electrolyte in the porous diaphragm either by the pressure of a gas present in the gas space or by the capillary depression pressure in the diaphragm, and by condensing the steam on a coolable condensation surface forming a boundary surface of the gas space opposite the diaphragm.

**5248 Hydrazine fuel cell.** Kohlmueller, H.; Naschwitz, W. (to Siemens AG). German(FRG) Patent 2,446,715/A/. 8 Apr 1976. 13p. (In German).
2 figs.

The task of the invention is to keep the spontaneous decomposition rate of the hydrazine as low as possible in hydrazine fuel cells in which an electrolyte/hydrazine mixture is led past the side of the hydrazine electrode turned away from the air or oxygen electrode, in a given direction. It is to guarantee at the same time that despite the slow flow rate of the electrolyte/hydrazine mixture, the whole electrode surface of all hydrazine electrodes is uniformly and sufficiently supplied with fuel. This is achieved according to the invention, in that a membrane is arranged on the electrolyte/hydrazine mixture flowed side of the hydrazine electrodes whose diffusion resistance decreases for hydrazine in the flow direction of the electrolyte/hydrazine mixture.

### PERFORMANCE AND TESTING

*REFER ALSO TO CITATION(S) 5158, 5159*

### MATERIALS, COMPONENTS, AND AUXILIARIES

**5249 Method for the fabrication of fuel cell electrodes for galvanic fuel elements.** Lindholm, I.; Mueller, B. (to Allmaenna Svenska Elektriska AB). German(FRG) Patent 1,281,512/C/. 16 Jan 1975. 4p. (In German).

The invention deals with a method to produce a porous fuel electrode material for galvanic fuel elements consisting of an electrochemically active material and possibly an inactive carrier material. Characteristics for this process according to the invention is that nickel boride is used as electrochemically active material and that boron possibly is at least partly extracted from the electrode material.

**5250 Fuel cell electrode.** Cohn, J.G.E.; Adlhart, O.J. (to Engelhard Industries, Inc., Newark, N.J. (USA)). German(FRG) Patent 1,471,800/C/. 20 Feb 1975. 7p. (In German).
11 tabs.

The invention deals with a fuel cell anode for acid electrolytes whose electrocatalysts are alloys of platinum and osmium or platinium and ruthenium. The patent claims deal with a) the weight perant of the mentioned alloys and b) the addition of 2 to 4 weight percent gold, tantalum, tungsten, rhenium, palladium, molybdenum, silver, niobium, rhodium, osmium or iridium to platinum-ruthenium alloys.

**5251 Method for fabrication of electrodes for acid electrolyte fuel cells.** Pohl, F.A.; Boehm, H. (to Licentia Patent-Verwaltungs-GmbH). German(FRG) Patent 1,596,166/C/. 20 Feb 1975. 2p. (In German).

The invention is based on the task of improving the electrodes of fuel elements with acid electrolytes regarding their electrochemical activity. This task is solved by the invention in that a mixture of two or several metal oxides of the transition metals titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, tungsten, iron, cobalt or nickel are converted into carbides by reaction with elementary carbon and are processed to electrode by pressing and then sintering.

**5252 Fuel cell electrode.** Pohl, F.A.; Boehm, H. (to Licentia Patent-Verwaltungs-GmbH). German(FRG) Patent 1,929,161/C/. 27 Feb 1975. 2p. (In German).

The invention concerns an anode of low-temperature fuel cells with acid electrolytes. The anode must be able to electrochemically use impure gaseous fuels or fuels dissolved in electrolytes very efficiently. According to the invention, the problem is solved in that the electrode contains a telluride or selenide of the elements molybdenum, tungsten or chromium as catalytically active material. In a few cases applied, the catalytic activity of the electrodes can be improved in that they additionally contain a molybdenum or tungsten sulphide. As the above-mentioned materials only have a slight electric conductivity, the conductivity of the electrodes may be usefully increased by using hard coal or tungsten carbide with a 10 to 50 volume per cent fraction.

**5253 Electrolyte carrier for fuel cells and method of its production.** Guillot, G.N.; Le Bras, C.R.; Louichon, M.G. (to Gaz de France). German(FRG) Patent 1,671,790/C/. 3 Apr 1975. 3p. (In German).

The invention deals with porous carriers of molten electrolytes as are used in high-temperature fuel cells. They are made of lithium aluminate (preferably $LiAlO_2$) and are permeated with an electrolyte corresponding to the eutectic mixture lithium carbonate/sodium carbonate. It is suggested to prepare such an electrolyte carrier by mixing aluminium salts or oxides, in particular $\gamma$-$Al_2O_3$, together with lithium carbonate and sodium carbonate in powder form, pressing this to pellets, annealing at about 700°C, then by crushing the thus obtained sintered bodies and annealing again at 950 to 1,000°C, where the initial mixture contains so much lithium carbonate that the excess not converted to lithium aluminate corresponds to the quantity necessary to form the eutectic mixture lithium carbonate/sodium carbonate.

## PHOTOVOLTAIC CONVERTERS

*REFER ALSO TO CITATION(S) 4655, 4656, 4657, 4661, 4664, 4669*

## POWER CYCLES

### BRAYTON

*REFER ALSO TO CITATION(S) 4622*

### RANKINE

*REFER ALSO TO CITATION(S) 4621*

### OTHER

**5254 Heat engine.** Birkmaier, W. German(FRG) Patent 2,400,175/A/. 17 Jul 1975. 5p. (In German).

1 fig.

It is the purpose of this invention to heighten the efficiency of a heat engine. This is done by liquefying the working medium - carbon dioxide or a substance with the same or similar properties - directly below its critical temperature, above which it cannot be liquefied even by the highest possible pressure.

## ELECTROMECHANICAL CONVERTERS

### SUPERCONDUCTING GENERATORS

*REFER ALSO TO CITATION(S) 5533*

**5255 Superconducting electrical generators for central power station use.** Flynn, T.M.; Powell, R.L.; Chelton, D.B.; Birmingham, B.W. (National Bureau of Standards, Boulder, CO). *Adv. Cryog. Eng.;* **19**: 35-43(1974).

The advantages offered by the application of the superconductivity in building very large generators are reviewed. Description of a program is given which was set up in order to develop a more effective way to generate and use electricity, utilizing superconductivity. The goal was to help solve the national energy crisis through better use of natural resources.

**5256 Cryogenic considerations in the development and operation of a large superconducting synchronous generator.** Jones, C.K.; Litz, D.C. (Westinghouse Electric Corp., Pittsburgh). *Adv. Cryog. Eng.;* **19**: 44-52(1974).

The use of superconducting windings in high-amplitude alternating magnetic fields is still not in general attractive at power frequencies, primarily due to the excessively large eddy current and hysteresis losses in any known material, thereby excluding from serious consideration, for the present, such applications as the stator windings of an ac machine. The size and weight reductions make superconducting machines attractive for electric-drive ship propulsion systems and for consideration for generation of power on electric utility systems. A number of small model machines of this type have already been built and successfully operated, demonstrating the feasibility of the idea. Results of an experiment to assess the potential technology are reported. A 5-MVA synchronous generator constructed has confirmed the feasibility of this innovation.

**5257 Superconducting alternator test results.** Bejan, A.; Keim, T.A.; Kirtley, J.L. Jr.; Smith, J.L. Jr.; Thullen, P.; Wilson, G.L. (Massachusetts Inst. of Tech., Cambridge, MA). *Adv. Cryog. Eng.;* **19**: 53-58(1974).

A research group at the Massachusetts Institute of Technology, supported by the Edison Electric Institute, has been studying the application of superconductors to the rotating field windings of alternators since early in 1967. Two machines have been constructed by this group. The first machine, which is rated at 45 kVA, has been discussed. Initial tests have been performed on the second superconducting alternator constructed. This presentation describes the operation of the machine during these tests, and outlines their results.

**5258 Alternating field losses in the superconductor for a large high-speed ac generator.** Walker, M.S.; Murphy, J.H.; Chang, Y.W.; Haller, H.E. III. (Westinghouse Research Lab., Pittsburgh). *Adv. Cryog. Eng.;* **19**: 59-66(1974).

This presentation reports an examination of the loss characteristics of a superconductor which has been used in the first phase of development of the rotating field winding for a 12,000-rpm, 400-Hz generator. Calorimetric measurements were performed on a small sample of the conductor at 4.2K in environments simulating those which might be encountered in the machine. The results are analyzed.

### SUPERCONDUCTING MOTORS

*REFER ALSO TO CITATION(S) 5533*

**5259 Shaped field superconductive dc ship drive systems.** Doyle, T.J. (Naval Ship Research and Development Center, Annapolis, MD). *Adv. Cryog. Eng.;* **19**: 162-170(1974).

A 400- to 1000-hp motor has been designed and constructed to verify the predicted size and performance advantages of the shaped field configuration. Presently the laboratory machine is undergoing no-load evaluation. This presentation describes the design and construction of the shaped field laboratory motor. Loss mechanisms are treated and machine performance estimated. The advantages that a superconductive dc drive can provide future high-performance ships are illustrated in a hypothetical 80,000-hp, small water area, twin hull (SWATH) ship and 40,000-hp hydrofoil (HF) craft.

# ENERGY CONSERVATION, CONSUMPTION, AND UTILIZATION

## BUILDINGS

*REFER ALSO TO CITATION(S) 5236*

### RESIDENTIAL

*REFER ALSO TO CITATION(S) 5168, 5169, 5232*

**5260 (PB—241919) Cost-effective methods to reduce the heating and cooling energy requirements of existing single-family residences. Final report.** Ackerman, A.D.; Hogarth, P.T.; Burke, B.J.; Stone, R.F. (Abt Associates, Inc., Cambridge, Mass. (USA)). Feb 1975. Contract HUD-H-2179. 185p. (AAI—75-19). NTIS $7.00.

The report investigates many practical ways to reduce energy consumed in the heating and cooling of family homes. Existing house construction types are studied, and energy conservation techniques that apply to these types are discussed with respect to cost and potential fuel savings.

## TRANSPORTATION AND PROPULSION

*REFER ALSO TO CITATION(S) 5234*

**5261 (PB—242408) Reading USAC project: vehicle management computer program module, release number one. Software.** George, H. (Reading, Pa. USAC Project (USA)). May 1975. Contract HUD-H-1212. 1 reel mag tape, vp. (USAC-IMIS-RDG—003). Specify tape recording mode desired: 9 track, 800 or 1600 bpi, odd parity, EBCDIC; or 7 track, 556 or 800 bpi, odd or even parity, BCD. Documentation available.

A tape was made which contains the USAC Municipal Vehicle Management Module for the Reading, Pennsylvania, In-

tegrated Municipal Information System (IMIS). The programs included on this tape produce from input cards a fuel consumption report. The cards are edited and then used as input to the program that produces a report by vehicle within Bureau showing fuel consumed during the reporting period. Totals are produced by vehicle by Bureau, and by fuel distribution point. There are 2 programs recorded on the tape. 32K bytes of core storage are needed to operate this module on a UNIVAC Model 9300 II computer. Technical documentation describing this module is available.

### AIR AND AEROSPACE

*REFER ALSO TO CITATION(S) 4372*

**5262** (N—75-24802) **Future space transportation systems systems analysis study, Phase I technical report.** (Boeing Aerospace Co., Seattle, Wash. (USA)). May 1975. Contract NAS9-14323. 363p. (NASA-CR—141856; D—180-18768-1). NTIS $10.00.

The requirements of projected space programs (1985-1995) for transportation vehicles more advanced than the space shuttle are discussed. Several future program options are described and their transportation needs are analyzed. Alternative systems approaches to meeting these needs are presented.

### RAILWAY

*REFER ALSO TO CITATION(S) 5280*

### LAND AND ROADWAY

*REFER ALSO TO CITATION(S) 5199*

**5263** (COM—75-10691) **NBS computerized carpool matching system: users' guide. Final technical report.** Gilsinn, J.F.; Landau, S. (National Bureau of Standards, Washington, D.C. (USA)). Dec 1974. 65p. (NBSIR—74-633). NTIS $4.25.

The report includes flowcharts, input/output formats, and program listings for the programs, plus details of the manual process for coordinate coding. The matching program produces, for each person desiring it, a list of others residing within a prespecified distance of him, and is thus applicable to a single work destination having primarily one work schedule. The system is currently operational on the National Bureau of Standards' UNIVAC 1108 computer and was run in March of 1974, producing lists for about 950 employees in less than four minutes computer time. Subsequent maintenance of the system will be carried out by the NBS Management and Organization Division. (GRA)

## INDUSTRY

*REFER ALSO TO CITATION(S) 4375, 5185, 5317*

### ENERGY SOURCES

*REFER ALSO TO CITATION(S) 4436, 4437*

### EQUIPMENT AND PROCESSES

*REFER ALSO TO CITATION(S) 5369*

**5264** (ANCR—1317) **Survey of industrial dryers for solids.** Richardson, A.S.; Jensen, W.P. (Idaho National Engineering Lab., Idaho Falls (USA)). Jul 1976. Contract E(10-1)-1375. 57p. Dep. NTIS $4.50.

A study was directed toward obtaining data for an estimate of the current and anticipated energy demand for industrial drying operations for solid materials. Twenty-seven dryer types, including those utilizing both direct and indirect heat sources, were identified and are described. Results of an analysis made on 17 dryer types and based on data obtained from several of the largest solids dryer manufacturers indicate that industrial dryers for solids currently consume about $1.3 \times 10^{18}$ J (1.2 quads) of energy. This represents nearly 4 percent of the total United States industrial energy use. Several examples of steps being taken by industry to reduce energy requirements for solids drying are included. Still further action to reduce energy consumption of dryers is possible; implementation will depend upon the extent to which incentives are provided by fuel scarcity, fuel costs, and the perfection of new technology by industry alone and in programs with the Federal Government.

**5265** (TID—27120) **Industrial thermal insulation: an assessment.** Donnelly, R.G.; Tennery, V.J.; McElroy, D.L.; Godfrey, T.G.; Kolb, J.O. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 215p. Dep. NTIS $8.00.

Revision of ORNL/TM—5283 and ORNL/TM—5515.

In keeping with the objectives given in a National Plan for Energy Research, Development and Demonstration, the more effective utilization of thermal insulation within the industrial sector has been identified as a potential program area for energy conservation. The Energy Research and Development Administration commissioned the Metals and Ceramics Division of the Oak Ridge National Laboratory to define the potentials of this program area. This report presents the findings of this study and includes a summary of an industry-wide workshop on the ORNL findings. The report also contains detailed descriptions of standard thermal test equipment used throughout industry and a directory of facilities having these equipments. The primary goals of this study were: (1) to identify potential energy savings available through use of insulation in the various elements of the industrial sector; (2) to assess the status of insulation technology, e.g., materials, design economics, and thermal property testing and performance; and (3) to identify R and R targets within the insulation technology that will accelerate the effective use of insulation. The report addresses the following major topics related to industrial thermal insulation: (1) available insulation materials for cryogenic through high temperature applications; (2) energy conservation potential for insulation in various industrial applications; (3) economic considerations for application of insulation; (4) availability of thermal property data; and (5) thermal property testing and specification of insulation materials. For each of the above areas, observations, conclusions and recommendations were listed, including proposed research and development targets. Since the scope of this assessment treated the various aspects of the insulation technology in a generic manner, it must be recognized that the observations and conclusions may not necessarily pertain to each specific commercial product or application area.

**5266** **Evaluation of improved silica ovens at Emil Plant of Bergbau-Forschung GmbH.** Rohde, W.; Stalherm, D.; Beck, K.G. In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

At the experimental coke oven plant run by Bergbau-Forschung, two groups of new silica ovens are in operation with stretchers 3 3/8 and 2 3/4 in. wide. In addition, one group is equipped with a new type of thickness checkers. Both groups are designed for programmed heating. The tests conducted have proved the reliability in service of high-productivity coke ovens with thin heating walls. The experimental ovens have been operating 2.5 y with carbonization times of 14 h at the utmost. The increased heat supply required for shorter coking times pre-supposes better heat exchange in the regenerator. This was accomplished by development of new thickness measuring bricks working with reversal times of less than 10 minutes, without enlarging the volume of the regenerator.

**5267** **Optimizing burden beneficiation to achieve improved energy balance.** Chang, M.C. (Korf Ind., Inc., Charlotte, NC). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

One of the biggest problems confronting the blast furnace operators is not knowing at all times what they are putting into the furnace due to quality variability. Because of this they tend to operate the furnace conservatively. To illustrate this, the article shows the monthly statistics of the cast by cast hot metal silicon analysis of a furnace which was being operated to meet hot metal sulfur of 0.03% or less. The extreme variability in hot metal silicon was due to highly variable chemistry of sinter and lump ore, which constituted approximately 70% of the burden, and possibly also the over-reaction by the operators making the corrections. The article also shows what the furnace actually saw, on a shift by shift basis, of a pellet charge which had a yearly average plus $^1/_4$ in. fraction of 94.5%.

**5268** **Optimization of fuel injection into the blast furnace.** Sciulli, C.M.; White, D.G. (U.S. Steel Corp., Monroeville, PA). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

The steps taken to ensure optimum fuel injection rates consistent with furnace blast and burden conditions were as follows: provide uniform distribution of the oil to the tuyeres around the furnace by increasing lance pressure differential; provide a high percent of injection-lance availability by preventing lance plugging; provide the best atomization of injected fuel within the limitations

of the injection system and ease of lance fabrication and maintenance; and provide the operators with charts and equations for use in determining individual-furnace total fuel injection rate consistent with combustibility and flame-temperature limitations.

**5269 Homogenized oil injection at Dofasco.** Ashton, J.D.; Holditch, J.E.R. (Domin Foundries and Steel, Ltd., Hamilton, Ont.). In Ironmaking conference. Lourie, D. (ed.). New York; Ironmaking conference (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

The homogenized oil process is simple in concept, mechanically sound, requires very little routine maintenance, and has proved to be an effective addition to Dofasco's fuel injection system. No major furnace operating problems have been experienced, either with homogenized oil alone or in conjunction with up to 3% $O_2$ enrichment in the blast.

**RECYCLING**

*REFER ALSO TO CITATION(S) 5271*

## ELECTRIC POWER

*REFER ALSO TO CITATION(S) 5270*

## WASTE MANAGEMENT

*REFER ALSO TO CITATION(S) 5170*

**5270 Solid waste management.** *Fed. Regist.* (*Wash., D.C.*); **41**: No. 184, 41202-41205(21 Sep 1976). (40CFR244).

From Protection of Environment, 40CFR244, Environmental Protection Agency—Solid waste management guidelines for beverage containers.

These guidelines attempt to clarify that any type of container is acceptable for use in implementing a returnable beverage container system as long as containers are returned and either reused or recycled, where markets for recyclable materials are available. Changes have also been made to increase the flexibility available to agencies and facilities in implementing such a system to ease the adaptation of the guidelines' requirements to local situations. (PCS)

**5271 Solid waste management.** *Fed. Regist.* (*Wash., D.C.*); **41**: No. 184, 41208-41211(21 Sep 1976).

From Protection of Environment, 40CFR245, Environmental Protection Agency—Promulgation resource recoverry facilities guidelines.

These guidelines provide requirements and recommended procedures for the establishment and utilization by Federal agencies of facilities to recover resources from residential, commercial, or institutional solid wastes, and recommend the establishment and utilization of such facilities to State, interstate, regional, and local governments. Utilization of resource recovery facilities will result in conservation of resources and in a reduction in the amount of solid waste that requires disposal.

# ADVANCED AUTOMOTIVE PROPULSION SYSTEMS

**5272** (CONF-751238—) **Symposium on low pollution power systems development, December 2—3, 1975, Rome, Italy.** (North Atlantic Treaty Organization, Brussels (Belgium). Committee on the Challenges of Modern Society). 1975. 126p. Dep. NTIS $6.00.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

The Third Symposium on Low Pollution Power Systems Development (LPPSD) was organized by the Ministry of Transport of Italy and held in Rome, December 2 and 3, 1975. Attendence was limited to representatives of the various participating governments. Each of the representatives briefly reviewed the status and plans for research on low pollution power systems for vehicles. A panel discussion of specific action items identified at the 1974 Dusseldorf Symposium included the following topics: (1) interaction between LPPSD and research safety vehicle projects; (2) analysis of exhaust emissions test methods and procedures - Europe and U.S.A.; (3) the urban and freeway traffic noise problem; and (4) multilateral cooperative research and development projects. Discussion of scope, content, and timing of future symposia revealed satisfaction with the results to date, but identified problem areas and a desire to improve future international cooperation to alleviate and share the expense of future cooperation. Each presentation is summarized along with the pertinent comments, questions, and items of discussion. Wherever possible specific data, principal conclusions, and key illustrations are included. The Appendix is a list of the attendees who participated in the Symposium. A separate abstract was prepared for each of the fourteen presentations for ERDA Energy Research Abstracts (ERA). (PMA)

**5273** (CONF-751238—, pp 50-55) **Bilateral or multilateral cooperative research and development projects.** Thur, G. (Div. of Transportation, Washington, DC). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

The current worldwide recession makes it more important than ever to cooperate, share, and not duplicate programs. This is the reason and purpose of the "Overlay Project," initiated at Dusseldorf in 1974. An overlay of all activity related to Low Pollution Power Systems Development (LPPSD) was determined to be necessary: to allow for better planning in the future, to have knowledge of dollars being invested in various areas, and to determine any overlap in programs among the various nations. The overlap of various programs is shown in graphical form with respect to the calendar year.

**5274** (CONF-751238—, pp 56-58) **Automotive power systems evaluation.** Stevenson, R.R. (Jet Propulsion Lab., Pasadena, CA). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

A brief discussion is given of a study to examine alternatives to the Otto cycle engine and to determine what should be done and when it should be done to gain significant advantages over the Otto engine and its likely evolutionary improvements. "What should be done" is asking for a value judgement, a statement, and a recommendation, and "when" brings up the question of the time-scale and phasing-in of any change. It is also recognized that the Otto engine has room for improvement and that, to a large extent, any alternate power plant is competing against a moving target.

**5275** (CONF-751238—, pp 78-103) **Some trends of Italian industry research toward the realization of low pollution vehicles.** Polletta, A. (Istituto Nazionale Motori, Naples). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

Research programs of two Italian motor vehicle manufacturers, Fiat and Alfa Romeo, are described. The Fiat research program on vehicle propulsion systems having low pollution characteristics and good fuel economy covers three areas: thermal engines; electric motors; and hybrid systems (energy accumulation). The engine types under investigation are: reciprocating, spark-ignited; reciprocating, compression-ignited (diesel); and rotary, Brayton cycle (gas turbines). The Alfa Romeo research is aimed at the general principles for car and power plant design, and the very philosophy of personal transport vehicles, with reference to present societal requirements: fuel consumption reductions, pollutant emission abatement, and safety. The main purpose set for the Alfa Romeo research is fuel economy in passenger car transport, and emission abatement to present and future legal limits is set as the necessary condition for a positive evaluation of the different solutions considered.

**5276** (CONF-751238—, pp 117-120) **United States Research and Development Program.** Brogan, J. (Energy Research and Development Administration, Washington, DC). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

The transportation research programs of the U.S. Energy Research and Development Administration are briefly discussed. Three heat engine systems are being developed, i.e., the gas turbine; the Stirling cycle system; and new versions of lightweight, light-duty diesels. Work on a Rankine cycle steam engine is virtually complete. Among the vehicle systems development projects are infinitely variable transmissions, accessory drives, and a bottoming cycle. Programs on alternative fuels and electric-powered vehicles are continuing. (PMA)

## INTERNAL COMBUSTION ENGINES

*REFER ALSO TO CITATION(S) 5299*

### SPARK-IGNITION

*REFER ALSO TO CITATION(S) 5279, 5290*

**5277** (UCRL—77621(Rev.1)) **Three dimensional numerical modeling of liquid fuel sprays.** Westbrook, C.K. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 1976. Contract W-7405-Eng-48. 30p. (CONF-760801—3). Dep. NTIS $4.00.

From 16. international symposium on combustion; Cambridge, Massachusetts, United States of America (USA) (15 Aug 1976).

A numerical solution technique was developed for the spray equation and applied to thin sprays injected into a type of stratified charge internal combustion chamber. The difference equation method can treat general three dimensional geometries, using a statistical approach. The effects of independent variations of a large number of system parameters were studied, including initial spray dispersion, amount and type of gas swirl, gas density, injection timing, chamber geometry, initial droplet size distribution, injection velocity, drag coefficient, vaporization rate expression, injector aperture size, droplet specific gravity, and direction of injection. It was found that, in the particular geometry chosen, the gas swirl, the droplet size distribution produced by the injector, and the chamber gas density into which the spray is injected are the most important factors influencing the spray motion and vaporization. Although the calculations reported applied to internal combustion engine conditions, the general method is applicable to other spray-injected combustors, including stationary combustors and rocket motors. Results from calculations indicate that the technique, used in coordination with selected laboratory measurements, could significantly enhance spray-injected combustor design efforts.

### DIESEL

*REFER ALSO TO CITATION(S) 5290, 5293*

**5278** (AD-A—010986) **Calibration of a Deutz F8L413 diesel and development of an on-board bhp-indicator. Test report.** Heggie, W.S. (National Research Council of Canada, Ottawa, Ontario). Feb 1975. 25p. (DME-MET—515). NTIS $3.25.

The calibration of a Deutz F8L413 diesel engine, emphasizing characteristics pertinent to the levitation of an Air Cushion Vehicle is described, together with the development of an output indicating device to be used aboard the craft. The opportunity was also taken to install NRC developed transducers for recording cylinder and fuel injection pressure-time phenomena, with the object of subjecting them to field endurance tests. Output and fuel consumption compared reasonably with manufacturer's data and a horsepower readout system was developed, based on fuel rack position and rotational speed. (GRA)

**5279** (CONF-751238—, pp 58-61) **United Kingdom's research and development program status.** Donald, G. (Dept. of the Environment, London). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

A summary is given of the status of key research and development programs related to Low Pollution Power Systems Development (LPPSD) which the United Kingdom is pursuing. Topics include: (1) diesel engine noise; (2) sodium-sulfur batteries; (3) pollution control equipment; (4) stratified charge engines; (5) diesel exhaust odors; and (6) fuel economy.

**5280** (PB—242232) **Per passenger-mile energy consumption and costs for suburban commuter service diesel trains. Final research report, Sep 1973—Aug 1974.** Walbridge, E.W. (Illinois Univ., Chicago (USA). Coll. of Engineering). Aug 1974. 65p. (RR—12). NTIS $4.25.

Results are presented based on data obtained from the three Chicago, diesel commuter railroads. Operations and equipment are described, particularly in terms of energy consumption and pollutant production. Service characteristics, such as average occupancy and average trip distance, and energy consumption results are presented and discussed.

### TURBINE

*REFER ALSO TO CITATION(S) 5287*

**5281** (COM—75-10754) **Marine gas turbine applications manual. Volume I. Heavy-duty gas turbine design, performance, and application data. Final report on Task 8 (Volume A).** Kaplan, S.M. (General Electric Co., Schenectady, N.Y. (USA). Gas Turbine Products Div.; Maritime Administration, Washington, D.C. (USA). Office of Marine Technology). 1 Apr 1975. Contract MA-0-35510. 178p. NTIS $7.00.

Maritime Administration, Washington, D.C. Office of Marine Technology.

A description is given of part of the work performed within Task 8, Marine Systems Engineering and Analysis of the Heavy-Duty Gas Turbine Development Program, or MARAD Project. The MARAD Project is an integrated effort to develop the heavy-duty gas turbine as an alternate competitive form of marine power generation. The costs of this program are shared equally by the U.S. Department of Commerce, Maritime Administration and the General Electric Company, Gas Turbine Products Division. This document represents one of three volumes of the Task 8 Final Report. It presents Vol. I, Design, Performance and Application Data of the Marine Gas Turbine Applications Manual developed in this task. This specific volume covers gas turbine design parameters, performance, and application data to permit owners, naval architects, and shipyards to select the correct gas turbine and to evaluate performance of the integrated system.

**5282** (N—75-22745) **DOT/NASA comparative assessment of Brayton engines for guideway vehicles and buses. Volume 2. Analysis and results.** (National Aeronautics and Space Administration, Cleveland, Ohio (USA). Lewis Research Center). 1975. 284p. (NASA-SP—354(Vol.2)). NTIS $8.75.

Gas turbine engines were assessed for application to heavy duty transportation. A summary of the assumptions, applications, and methods of analysis is included along with a discussion of the approach taken, the technical program flow chart, and weighting criteria used for performance evaluation. The various engines are compared on the bases of weight, performance, emissions and noise, technology status, and growth potential. The results of the engine screening phase and the conceptual design phase are presented.

## EXTERNAL COMBUSTION ENGINES

*REFER ALSO TO CITATION(S) 5299*

### STIRLING CYCLE

*REFER ALSO TO CITATION(S) 5293*

## ELECTRIC-POWERED SYSTEMS

*REFER ALSO TO CITATION(S) 5172, 5173, 5174, 5175, 5181, 5182, 5193, 5194, 5195, 5196, 5233, 5279, 5290, 5291*

**5283** (AD-A—011129) **Electric vehicle research, development and technology: foreign.** Busi, J.D.; Turner, L.R. (Defense Intelligence Agency, Washington, D.C. (USA)). Jun 1975. 146p. (DST—1850S-403-75). NTIS $5.75.

The development and production of electric drive vehicles have been successful in the Federal Republic of Germany, Japan, the United Kingdom, the USSR, and to a lesser degree in France, Italy, and Sweden. These vehicles are basically designed for commercial or industrial applications and, in general, a typical vehicle of this type has a maximum range of 60 to 150 miles and a maximum speed of 60 mph. Military applications of electric drive vehicles for transportation and combat are significant because they offer a number of advantages over more conventional drive systems.

**5284** **High-speed transportation levitated by superconducting magnet.** Oshima, K.; Kyotani, Y. (Tokyo Univ.). *Adv. Cryog. Eng.;* **19**: 127-136(1974).

Results of preliminary studies on superconducting magnet levitation in Japan are presented. The review presented gives a summary of the experimental studies performed to date by the Japanese National Railways. Additional experimental and theoretical work is being carried out simultaneously in both industry and universities. Plans have now been formulated to perform a field test of a levitated superconducting magnet vehicle at the speed of 500 km/hr on a 7-km track in 1975. Studies for designing the test vehicle are presently under way and it is expected that this test will open the way to final development and design of the actual train which has to be completed by around 1977.

## HYBRID SYSTEMS

*REFER ALSO TO CITATION(S) 5290*

## VEHICLE DESIGN FACTORS

*REFER ALSO TO CITATION(S) 5288*

**5285** (CONF-751238—, pp 11-30) **Research Safety Vehicle (RSV) program.** Esposito, V.J. (Dept. of Transportation, Washington, DC). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

The RSV Program considers societal goals in energy, economy, and environment as well as safety. The specific goals may be summarized as follows: (1) the safety goal to design a vehicle weighing less than 3000 pounds which will reduce, to the maximum extent practical, the societal costs of automobile accidents in the 1985 time period; (2) the energy goal to achieve a fuel economy level of 30 mpg for the EPA-combined cycle (this objective, originally a secondary or complimentary goal to the safety goal, has now become a primary goal of equal importance to safety); (3) in the area of economy, to have careful constraints on production and maintenance costs, and also all features included on the RSV are to produce a societal benefit which is greater in value than the life-cycle cost of the feature; and (4) in the area of environment, the vehicle is to meet or exceed the 1977 EPA Emission Standards. Phase I of the RSV Program was completed in May 1975, and the results are summarized. The objectives of this phase were to define the role and projected operating environment for the family-size vehicle of the mid-1980's and to develop the performance specification for this vehicle based on societal benefits versus cost.

**5286** (CONF-751238—, pp 33-50) **Urban and freeway traffic noise problem.** Schettino, J.C. (Environmental Protection Agency, Washington, DC). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

The urban and freeway traffic noise problem, a challenge to modern society, is discussed. The topics covered are: (1) extent and nature of urban traffic noise; (2) characteristics of major sources of transportation noise; (3) U.S.A. surface vehicle noise research and development programs; (4) U.S.A. noise emission regulatory options; and (5) proposed LPPSD projects. The first four topics provide a basis for considering several noise abatement and control projects which are suggested.

### ENGINE SYSTEM

*REFER ALSO TO CITATION(S) 5282*

**5287** (N—75-21633) **The aerodynamic design of a compressor-drive turbine for use in a 75 kW automotive engine.** Roelke, R.J.; Mclallin, K.L. (National Aeronautics and Space Administration, Cleveland, Ohio (USA). Lewis Research Center). Apr 1975. 39p. (NASA-TM-X—71717). NTIS $3.75.

The design of a single stage axial-flow turbine with a tip diameter of 11.15 cm is presented. The design specifications are given, and the aerodynamic design procedure is described. The aerodynamic information includes the results of flow path, velocity diagram, and blade profile studies. Predicted off-design performance characteristics are also presented.

## EMISSION CONTROL

*REFER ALSO TO CITATION(S) 5174, 5181, 5182, 5279, 5683*

**5288** (CONF-751238—, pp 8-11) **Interaction between LPPSD and RSV projects.** Saraceni, A. 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

An analysis of the interaction between Low Pollution Power Systems Development (LPPSD) and Research Safety Vehicle (RSV) projects, confined to vehicles equipped with conventional engines, is presented. The possible influence on traffic safety is examined for all measures directed at reducing those parameters which make the conventional vehicle a source of pollution (gaseous, solid, and noise emissions). The inverse problem is also reviewed; i.e., the evaluation of the possible influences of traffic safety measures on the polluting emissions from vehicles equipped with conventional engines. A review is given of the influence on safety of vehicles provided with nonconventional, low-pollution alternative systems.

**5289** (CONF-751238—, pp 30-33) **Analysis of the exhaust emissions test methods and measuring procedures in Europe and the U.S.A.** Martin, K.U. 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

At the 1974 Symposium in Dusseldorf, it was decided to inform in the future all member countries on internationally significant research projects and to exchange the results pertaining to them. Additionally, it was agreed to designate some members as pilot countries for the implementation of different projects. In this connection, the Federal Republic of Germany consented to be the Pilot Country for the project "Possibilities of Harmonizing the Legally Provided Test Procedures for Exhaust and Noise Emissions in the United States and Europe." To obtain scientifically certain results on this complex subject, three R and D projects were given to industrial establishments. The total cost will amount to 2.5 million DM (one million dollars); the projects will take two years, ending by mid-1977. A brief survey of the first activities is given.

**5290** (CONF-751238—, pp 61-65) **Federal Republic of Germany: Research and Development Program.** Schoenfeld, A. 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

At the second symposium in Dusseldorf last year, two major research and development programs in the field of Low Pollution Power Systems Development (LPPSD) were reported. These are the "traffic emissions program" and the "vehicle and traffic technology program." Continued progress on these programs is reported.

**5291** (CONF-751238—, pp 65-70) **Research on the reduction of emission levels in French vehicles, 1972—1975.** Lamure, C. (Inst. for Transportation Research, St. Jean, France). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

The French Government is considering in the next ten years the possibility of reasonable reductions of air pollution and noise from motor vehicles. These reductions will be important enough to require vehicle improvements, but will not require entirely new propulsion systems. Hence, no prototypes of new thermal engines are on the board; only studies of a new bus prototype are planned for 1976. However, work will be expedited on electric vehicles and on technical evaluation studies of new vehicles. Research concerned with reduction of noise and air pollution from motor vehicles and with electric vehicles is discussed.

**5292** (CONF-751238—, pp 70-78) **Status of automobile air pollution control in the United States.** Stork, E. (Environmental Protection Agency, Washington,DC). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

A discussion is given of the status of, and prospects for, pollution control requirements for automobiles in the U.S. This subject has a significant relationship to hardware development of alternative power systems; to a large extent, the degree of emission control required to be achieved is the purpose of the hardware development effort.

**5293** (CONF-751238—, pp 104) **Netherlands Research and Development Program.** Meekel, G. (Ministry of Transport and Public Works, The Hague, Netherlands). 1975.

From Symposium on low pollution power systems development; Rome, Italy (3 Dec 1975).

In Symposium on low pollution power systems development.

The Dutch policy of reducing the noise and air pollution emissions is considered very important. In support of this policy, the Dutch Government has two contracts in preparation, and a brief description of each is given.

**5294** (PB—242092) **Consultant report on an evaluation of catalytic converters for control of automobile exhaust pollutants.** Hightower, J.W.; Butt, J.B.; Ollis, D.F.; Wise, H. (National Research Council, Washington, D.C. (USA). Committee on Motor Vehicle Emissions). Sep 1974. Contract EPA-68-01-0402. 129p. NTIS $5.75.

An assessment was made of the status of catalysts for automotive emissions control and estimates of the future developments in catalytic converters, especially for oxides of nitrogen removal. The basic performance characteristics and durability, materials supply, toxicology of emissions, and kinetics and modeling of automobile catalysts are discussed.

**5295** (PB—242094) **Consultant report on manufacturability and costs of proposed low-emissions automotive engine systems.** Lindgren, L.H.; Ebner, M.; Gay, H.A.; Johnson, W.A.; Kittrell, J. (National Research Council, Washington, D.C. (USA). Committee on Motor Vehicle Emissions). Nov 1974. Contract EPA-68-01-0402. 328p. NTIS $9.50.

An assessment was made of the capability of the U.S. automotive industry to produce a variety of emissions control technology for internal combustion engines and to compare the associated fuel, maintenance, sticker price, and investment-cost penalties to the driving public.

**5296** (PB—242247) **Medium duty vehicle emission control cost effectiveness comparisons. Volume II. Technical discussion.** Hinton, M.G.; Meltzer, J.; Iura, T.; Drake, J.A.; Forrest, L. (Aerospace Corp., El Segundo, Calif. (USA). Urban Programs Div.). Jan 1974. Contract EPA-68-01-0417. 237p. (ATR—74(7327)-1(Vol.2)). NTIS $7.50.

Light-duty vehicles (LDVs--under 6,000 lb GVW) and medium-duty vehicles (MDVs) selected to form the basis of cost factor comparisons are characterized and delineated. The specific emission control systems used in LDV and MDV cost calculations, the characteristics or baseline emission levels prior to incorporation of emission control systems, and the lifetime costs attributable to emission control are discussed. A comparison and discussion are given of LDV and MDV cost factors (expressed as dollars expended per ton of pollutant removed) as a function of emission control system type and as a function of percent reduction in emission rate are summarized. The heavy-duty vehicle (HDV--over 14,000-lb GVW) cases examined are summarized. A summary overview of emission control cost factors associated with power plants and other stationary sources is given. A review of numerous transportation planning studies for selected air quality control regions (AQCRs), with emphasis on vehicle class distribution (LDV, MDV, and HDV) and annual mileage contributions is presented. Emission inventories are included for LDVs MDVs, and HDVs for the New York City, Los Angeles, and Phoenix/Tucson AQCRs.

**5297** **Estimated changes in human exposure to suspended sulfate attributable to equipping light-duty motor vehicles with oxidation catalysts.** Finklea, J.F. (National Environmental Research Center, Research Triangle Park, NC); Moran, J.; Knelson, J.H.; Turner, D.B.; Niemeyer, L.E. *Environ. Health Perspect.*; **10**: 29-34(Apr 1975).

The 3 independent techniques used to appraise community exposures include dispersion models developed for emissions of stable gases from motor vehicles and ambient carbon monoxide (CO) data to estimate sulfate ($SO_4^{-2}$) air quality changes, the use of carboxyhemoglobin levels in nonsmokers living in major cities to estimate existing CO exposures and anticipated incremental $SO_4^{-2}$ exposures, and the use of Pb surrogate data to estimate short-term incremental $SO_4^{-2}$ concentrations. Incremental increases in suspended $SO_4^{-2}$ and sulfuric acid aerosols are evaluated in terms of the number of vehicles equipped with oxidation catalysts. When 2 model years are equipped with catalysts, the "adverse case" projections of incremental 24-hr $SO_4^{-2}$ exposures range from 4 to 9 $\mu g/m^3$. These values are increased 4 fold after all the vehicles on the roads are equipped with catalysts. Adverse health effects among the most susceptible group of commuters traversing the busiest expressways will probably not be measurable after 1 model yr is equipped with catalysts but are likely by the end of the 2nd model yr. EPA weighed the established pollution abatement benefits of the reduction of hydrocarbon and CO emissions and the gasoline economy benefits of the catalysts against the projected $SO_4^{-2}$ problem and judged that catalysts should not be banned. Because of possible adverse health effects related to the incremental $SO_4^{-2}$ exposure in the future, an accelerated study program is being implemented.

### NITROGEN OXIDES

**5298** (PB—242091) **Consultant report on field performance of emissions-controlled automobiles.** Brattain, R.R.; Gockel, J.L.; McDowell, D.J. (National Research Council, Washington, D.C. (USA). Committee on Motor Vehicle Emissions). Nov 1974. Contract EPA-68-01-0402. 86p. NTIS $4.75.

An evaluation was made of the feasibility of maintaining the automotive emissions control systems and engines which will be manufactured to meet various exhaust-emissions standards for oxides of nitrogen, hydrocarbons, and carbon monoxide so that these systems and engines will meet the standards in actual use. The present condition of the service industry, progress toward enforcing proper maintenance, and the impact of political actions and social attitudes on progress are discussed.

**5299** (PB—242097) **Consultant report on emissions control of engine systems.** John, J.E.A.; Henein, N.A.; Jost, E.M.; Wulfhorst, D.; Bjerklie, J.W. (National Research Council, Washington, D.C. (USA). Committee on Motor Vehicle Emissions). Sep 1974. Contract EPA-68-01-0402. 274p. NTIS $8.50.

An evaluation was made of the potential of conventional, spark-ignition internal-combustion engines and other internal-combustion engines, such as rotary, diesel and stratified-charge engines, for meeting strict levels of oxides of nitrogen emissions control in conjunction with specified levels of unburned hydrocarbon and carbon monoxide emissions. The potential of alternative, more advanced automotive engines, such as the gas turbine, Stirling, and Rankine power plants, for meeting similarly strict levels of emissions control were assessed.

**5300** (PB—242246) **Medium duty vehicle emission control cost effectiveness comparisons. Volume I. Executive summary.** Hinton, M.G.; Meltzer, J.; Iura, T.; Drake, J.A.; Forrest, L. (Aerospace Corp., El Segundo, Calif. (USA). Urban Programs Div.). Jan 1974. Contract EPA-68-01-0417. 57p. (ATR—74(7327)-1(Vol.1)). NTIS $4.25.

Results are presented of a comparative analysis of the cost effectiveness of medium-duty vehicles. A concise review of important findings and conclusions is given, and a comparison is made of emission control cost factors (expressed as dollars expended per ton of pollutant removed) of medium duty vehicles (MDVs--6000 to 14000-lb GVW), light duty vehicles (LDVs--less than 6000-lb GVW), heavy duty vehicles (HDVs--greater than 14000-lb GVW), utility power plants, and a number of other stationary sources. Mobile source emission inventories were calculated for the New York City, Los Angeles, and Phoenix-Tucson Air Quality Control Regions. The results indicate that, in the mobile source area, emission control cost factors ($/ton) in general decrease in numerical value as the vehicle weight increases. This same size effect was noted in stationary source cost factor comparisons, where the cost factors decreased in numerical value as the system size (or flow rate of the product being controlled) increased.

### CARBON MONOXIDE

*REFER ALSO TO CITATION(S) 5297, 5298, 5299, 5300*

### SULFUR DIOXIDE

*REFER ALSO TO CITATION(S) 5297*

### HYDROCARBONS

*REFER ALSO TO CITATION(S) 5298, 5299, 5300*

**5301** (PB—242093) **Consultant report on emissions and fuel-economy test methods and procedures.** Matula, R.A. (National Research Council, Washington, D.C. (USA). Committee on Motor Vehicle Emissions). Sep 1974. Contract EPA-68-01-0402. 163p. NTIS $6.25.

An assessment was made of the reliability and reproducibility of the test methods and procedures for automotive emissions and fuel economy measurements. The effect of ambient temperature on exhaust emissions, emissions control durability, test methods, measuring techniques for only reactive hydrocarbons emissions, and evaporative hydrocarbon emissions test methods are discussed.

## ALTERNATIVE FUELS

*REFER ALSO TO CITATION(S) 4634*

**5302** (CONF-750410—11) **Performance of an ethanol-gasoline blend in automobiles and light trucks.** Scheller, W.A.; Mohr, B.J. (Nebraska Univ., Lincoln (USA). Dept. of Chemistry). 9 Apr 1976. 17p. University of Nebraska, Lincoln.

From 169. national meeting, American Chemical Society; Philadelphia, Pennsylvania, USA (6 Apr 1975).

A description is given of a two million mile road test program, now being conducted, to evaluate the use of a 10 percent anhydrous ethanol—90 percent unleaded gasoline mixture as an automotive fuel. The testing also includes unleaded gasoline as a control fuel. The objectives of the program are to obtain quantitative data on fuel consumption, cylinder wear, and exhaust gas

composition; and qualitative information on the condition of valves and valve seats, spark plugs, and the exhaust system. Some initial results are presented. (PMA)

**5303** (N—75-22901) **Technology assessment of portable energy RDT and P, Phase 1. Executive summary report.** Spraul, J.R. (TRW Systems, Redondo Beach, Calif. (USA)). 7 Apr 1975. Contract NAS2-8445. 13p. (NASA-CR—137654). NTIS $3.25.

A technology assessment of transportation energy research, development, technology, and production was undertaken to assess the technical, economic, environmental, sociopolitical issues associated with transportation energy options, and to determine those courses of action impacting aviation and air transportation research and technology. A technology assessment workshop was used to determine the problem statements that would be considered. Study tasks are summarized along with the problem statements.

**5304** (N—75-22902) **Technology assessment of portable energy RDT and P, Phase 1. Final report.** Spraul, J.R. (TRW Systems, Redondo Beach, Calif. (USA)). 7 Apr 1975. Contract NAS2-8445. 240p. (NASA-CR—137653). NTIS $7.50.

A technological assessment of portable energy research, development, technology, and production was undertaken to assess the technical, economic, environmental, and sociopolitical issues associated with portable energy options. Those courses of action are discussed which would impact aviation and air transportation research and technology. Technology assessment workshops were held to develop problem statements. The eighteen portable energy problem statements are discussed in detail along with each program's objective, approach, task description, and estimates of time and costs.

# MATERIALS

**5305** (ERDA—76/123) **Materials Sciences Programs, FY 1976.** (Energy Research and Development Administration, Washington, D.C. (USA). Div. of Physical Research). 1976. 133p. Dep. NTIS $6.00.

Materials research is being conducted by the Metallurgy and Ceramics, and the Solid State Physics and Materials chemistry branches. This report provides a convenient compilation and index of the research projects. It summarizes the projects according to the laboratories and universities; funding levels are also listed. An index is included. (DLC)

**5306** (UCID—17226) **Transferring the technology of welding and bonding: hands-on courses at LLL make it possible.** Jensen, C.W.; Hugenberger, C.E. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 15 Aug 1976. Contract W-7405-Eng-48. 30p. Dep. NTIS $4.00.

The technology training program at LLL is summarized. The program is directed toward transfer of unclassified laboratory technology to government and private-industry employees. Information is included on technology training program (TTP) organization, facilities and equipment, and participating companies and government agencies. A five-day training program on joining, fastening, and welding is outlined. (JRD)

**5307** **Microstructural science. Volume 4. Conference held in Bloomington, Minnesota, July 1 to 2, 1975.** Filer, E.W.; Hoegfeldt, J.M.; McCall, J.L. (eds.). New York; Elsevier Publishing Co., Inc. (1976). 381p. (CONF-750774—). $37.50.

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

The 34 papers are arranged into sections dealing with ferrous and nuclear materials; materials studies utilizing SEM, microprobe, and Auger; wood technology; biomedical materials; nonferrous materials; fatigue studies and fracture analysis; and methods evaluation for metallographic analysis. Separate abstracts were prepared for 9 of the papers; two of the remaining papers were previously abstracted as NSA 32: 20411 and 22851. (DLC)

## METALS AND ALLOYS

**5308** (ORNL—5157) **Liquid Metal Fast Breeder Reactor materials development program. Quarterly progress report for period ending March 31, 1976.** Patriarca, P.; Donnelly, R.G.; Duke, J.M.; Harkness, S.D.; King, R.T.; Shuster, E.; Slaughter, G.M. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 152p. AT.

Research progress is reported in chapters on steam generator materials development for CRBRP, alternate LMFBR structural materials, large diameter pipe and fitting development, and advanced absorber materials. (JRD)

**5309** (RDT-M—2-18T) **Precipitation hardening nickel alloy bars, forgings, and forging stock for high-temperature service (ASTM A 637) with additional requirements).** (Energy Research and Development Administration, Washington, D.C. (USA). Div. of Reactor Development and Demonstration). Apr 1976. Contract W-7405-eng-26. 9p. RSO.

(This supersedes the Dec. 1974 issue of RDT-M-2-18T.) This standard covers PH Ni alloy bars, forgings, and forging stock for nuclear and associated applications other than those under the jurisdiction of ASME Boiler and Pressure Vessel Code Section III. (DLC)

**5310** (UCRL—50028-76-2) **H-Division quarterly report, April—June 1976.** (California Univ., Livermore (USA). Lawrence Livermore Lab.). 14 Jul 1976. Contract W-7405-Eng-48. 51p. Dep. NTIS $4.50.

The purview of H-Division is the mechanics of fluids and solid bodies. Concise status reports of the projects undertaken by the various groups in the division are given. Representative topics studied include equations of state of various materials, fracture mechanics, penetration of armor by projectiles, turbulence generation, and the development of dynamics computer codes. 31 figures, 2 tables. (RWR)

**5311** (Y/DA—6661) **Ultrasonic and impact techniques used to characterize liquid-phase-sintered tungsten alloys.** Moyer, M.W.; Oakes, R.E. Jr. (Oak Ridge Y-12 Plant, Tenn. (USA)). 1976. Contract W-7405-eng-26. 14p. (CONF-760540—8). Dep. NTIS $3.50.

From Conference on high density alloy penetrator materials; Charlottesville, Virginia, United States of America (USA) (24 May 1976).

The Oak Ridge Y-12 Plant has been involved in producing liquid-phase-sintered tungsten alloys for penetrator applications. The majority of the effort has been centered on two materials—a 90 W-7 Ni-3 Fe alloy with 25 percent cold work and a 95 W-3.5 Ni-1.5 Fe alloy with 18 percent cold work. Fracture toughness concepts, along with instrumented Charpy impact tests, were used to measure toughness differences and temperature effects on toughness for several alloys. The instrumented Charpy was useful in screening alloys having different processing parameters. Ultrasonic techniques can be used to detect conditions of matrix depletion and incomplete sintering. Spectral analysis shows high attenuation of all frequencies in areas of matrix depletion and very low attenuation of energy between 10 and 15 MHz for conditions of incomplete sintering when compared to normal material. Efforts are underway to develop a higher density alloy. Of major concern in the higher tungsten alloys is cracking which may occur during swaging. Preliminary ultrasonic techniques to detect cracks are discussed.

**5312** **Metallographic examination of a failed Jewett nail-plate from a human femur.** Gray, R.J. (Oak Ridge National Lab., TN); Zirkel, L.G. Jr. pp 179-189 of In Microstructural science. Vol. 4. Filer, E.W. (ed.). New York; Elsevier Publishing Co., Inc. (1976).

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

See CONF-750774—.

A type 316L wrought stainless steel Jewett nail-plate is one of several implant designs for bridging fractures in the proximal end of the femur. A soldier received a high velocity projectile in the trochanteric region of the femur. He was treated for a subtrochanteric fracture and greater trochanteric bone loss. After 9 months, hip varus angulation was progressively increasing. A Jewett nail-plate was inserted after valgus osteotomy and bone grafting of the unhealed fracture. The nail-plate fractured three weeks after surgery. Optical and scanning electron microscopy related the origin of failure to an impactor failure and subsequent microscopic scoring of the nail-plate during insertion into the abnormally hard femoral head. Photomicrographs showing the implant failure and evidences of corrosion after the short time in the body are presented. 12 figs.

### PREPARATION AND FABRICATION

*REFER ALSO TO CITATION(S) 4375, 4437, 4438, 5421, 5483, 5484, 5529*

**5313** (BDX—613-1248) **Burrs produced by drilling.** Gillespie, L.K. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 107p. Dep. NTIS $5.50.

Component parts of small precision mechanisms typically require nearly sharp edges to assure reliable operation. A burr-free condition also is needed to minimize a possible jamming of the mechanism because of burrs breaking loose. Small burrs are easily removed by many deburring processes. Increasing the feedrate resulted in longer exit burrs from 303Se stainless steel and 1018 steel. Drill geometry, workpiece materials, and workpiece thickness also affected the exit-burr length. Radial-lip drills produced shorter exit burrs at fast feedrates in 303Se stainless steel than did the other drills, and they produced thinner exit burrs at all feedrates. Little difference was observed in the results from different drill points used in other materials. Burr size varied with the number of holes drilled in a typical wear-life pattern. Exit-burr thickness was a linear function of exit-burr length for the stainless steel specimens. No relationship between these properties was observed for either 1018 steel or 6061-T6 aluminum. The use of a backup material having a hole equal in diameter to that of the drill resulted in significantly shorter and thinner exit burrs than did any other drilling method studied.

**5314** (BDX—613-1372) **Burrs produced by grinding.** Gillespie, L.K. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 34p. Dep. NTIS $4.00.

An investigation was conducted to determine the influence of variables in controlling the size and repeatability of grinding burrs to minimize burr-removal costs and improve the quality and reliability of parts for small precision mechanisms. Each of the three types of burrs produced by surface-grinding a rectangular block responds differently to changes in cutting conditions. Reducing the downfeed rate generally produces shorter burrs. Although the size of the abrasive grain affected the thickness of one of the burrs, thickness was relatively unaffected by the variables studied. The thickest burrs occurred on low-carbon steel.

**5315** (BDX—613-1386(Rev.)) **Small powder parts.** Patterson, E.P. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 29p. Dep. NTIS $3.50.

Infrequently used techniques for assembling simple powder shapes into complex arrangements have been successfully employed in the fabrication of small sintered metal parts for use in miniature electromechanical devices. These parts can be produced from plain high- and low-carbon steels, stainless steels, and various other alloys of steel, copper, nickel, and aluminum, as well as refractory metals. Unit costs are only a fraction of those for comparable machined parts.

**5316** (LBL—5128) **Transport aspects of electrochemical machining and electrometallurgy.** Muller, R.H. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). May 1976. Contract W-7405-ENG-48. 35p. (CONF-760823—7). Dep. NTIS $4.00.

From Meeting of the American Institute of Chemical Engineers; Atlantic City, New Jersey, United States of America (USA) (27 Aug 1976).

Transport processes in large measure determine the rate at which electrolytic metal deposition and dissolution can be conducted. Unusually high rates, often accompanied by the formation of solid reaction products, are achieved in electrochemical machining by the use of high electrolyte flow velocities between closely-spaced electrodes. Geometrical shape and surface finish resulting from deposition or dissolution reactions are determined by the current distribution on a macroscopic and microscopic scale. Macroscopic current distributions have been determined experimentally by different electrical and optical means and are compared to theoretical expectations based on transport correlations and numerical models.

**5317** **Theoretical energy requirements for ironmaking.** Robins, N.A. (Inland Steel Co., East Chicago, IN). In Ironmaking conference. Lourie, D. (ed.). New York; American Inst. of Mechanical Engineers (1975).

From 34. ironmaking conference; Toronto, Ontario, Canada (13 Apr 1975).

Theoretically, the reduction of one ton of iron from hematite requires 322.6 lbs of oxygen; and an additional 201.4 lbs of carbon and 536.6 lbs of oxygen are required to supply the heat required for reduction and melting. The purpose of this paper is to show how the amounts of carbon and oxygen required to produce one ton of liquid iron change from the purely ideal process toward a more realistic process. The general procedure is to approach each process as one approaches a reaction--i.e., the energy required will be determined as the difference between the heats of formation of the products and the heats of formation of the reactants. 5 refs.

**5318** **Microporosity in cast Co—Cr—Mo hip prostheses.** Bardos, D.I.; Parker, M.E. (Zimmer, USA, Inc., Warsaw, IN). pp 135-143 of In Microstructural science. Vol. 4. Filer, E.W. (ed.). New York; Elsevier Publishing Co., Inc. (1976).

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

See CONF-750774—.

Precision castings for such surgical implants as hip prostheses are made by the investment casting process. Attempts to provide the highest quality castings for this critical application depend heavily on nondestructive test methods. Current NDT procedures are not adequate to detect amount of microporosity observed in Co—Cr—Mo alloy (ASTM F-75) castings. Microscopic methods were employed in an attempt to analyze the porosity from morphologic and quantitative points of view. Variations in sample preparation procedure were found to have a minor influence on the microscopic observations. Castings of several foundries are also discussed. 18 fig. (auth)

**5319** **Preparation and characterization of ultrathin Pb and In films on PbTe and Te.** Miller, D.L. (Brookhaven National Laboratory, Upton, New York 11973). *J. Vac. Sci. Technol.;* **13**: No. 6, 1138-1143(Nov 1976).

Ultrathin 10—300-A films of Pb and In have been prepared by evaporation in ultrahigh vacuum onto single crystal PbTe and Te substrates at low temperatures. Epitaxial growth was obtained for both metals deposited on PbTe (100) at 77 K, but not on Te (1010). Low energy electron diffraction, Auger electron spectroscopy, and low energy electron energy loss measurements were used to characterize substrates and films. Values of low energy electron escape depths through Pb, In, and PbTe were also obtained. (AIP)

**5320** **Substrate surface contamination from dark-space shielding during sputter cleaning.** Kominiak, G.J.; Uhl, J.E. (Sandia Laboratories, Albuquerque, New Mexico). *J. Vac. Sci. Technol.;* **13**: No. 6, 1193-1194(Nov 1976).

Soft x-ray appearance spectroscopy is used to monitor nickel contamination levels in an iron substate during glow discharge sputter cleaning, most severe surface contamination is introduced from an electrically floating stainless steel shield during dc sputter cleaning. Grounding the shield minimizes the contamination and rf sputtering virtually eliminates it.(AIP)

## STRUCTURE AND PHASE STUDIES

*REFER ALSO TO CITATION(S) 5163*

**5321** (CONF-760731—2) **Equilibrium structures of Type 304 and Type 316 stainless steel in the temperature range 800°F to 1500°F: a metallographic review.** Bagnall, C.; Shiels, S.A. (Westinghouse Electric Corp., Madison, Pa. (USA). Advanced Reactors Div.). 1976. Contract E(11-1)-3045. 15p. Dep. NTIS $3.50.

From 9. Annual International Metallographic Society meeting; Seattle, Washington, United States of America (USA) (25 Jul 1976).

The phase diagrams depicted in this report serve as a general guide to the structures that may be found in Type 304 and Type 316 stainless steels as thermodynamic equilibrium is approached. The influences of cold work and stress, however, are not indicated but will tend to cause reactions to proceed more rapidly or to take place where they are not normally favored. A large change in grain size from those shown (ASTM 8-9), will also have an effect on the distribution of the second phases. The proposed mechanism for sigma formation in Type 304 SS requires substantiation with additional experimental evidence over the 1100-1500°F temperature range using material containing carbon up to the H-grade level of 1000 ppM.

**5322** (LBL—4962) **Lattice image and optical diffraction studies of alloys.** Thomas, G.; Sinclair, R.; Gronsky, R. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Mar 1976. Contract W-7405-ENG-48. 8p. (CONF-760928—2). Dep. NTIS $3.50.

From 6. European Congress on electron microscopy; Jerusalem, Israel (14 Sep 1976).

Progress in applying lattice imaging to problems in alloys at the atomic level is reviewed. This has been illustrated by results on unit cell high steps in interfaces in ordered $Mg_3Cd$, on direct and reciprocal space studies of spinodal decomposition in Au-Ni and on grain boundary precipitation in Al-Zn. These observations, at present, are unique in the metallurgical field. Direct images have been complemented by optical diffraction patterns, with the possibility of using selecting apertures down to 10A in diameter, which is a considerable reduction over conventional electron diffraction. Such apertures are also smaller than areas currently selected by the beam size in scanning transmission electron microscopy. The microdiffraction capability is being used to solve ambiguous, conventional diffraction patterns, such as those obtained from short-

range ordered alloys, and for more complex patterns, as for instance obtained from ordered stacking structures in SiC. The optical patterns from larger areas are also compared with the original electron diffraction patterns to ensure that the lattice image contains the pertinent information of the specimen lattice. It is noted that lattice imaging is assuming an important role in studying fundamental aspects of materials science.

**5323** (LA-tr—76-20) **Determination of the dislocation density in polycrystalline, cubic-lattice metals.** Oettel, H. Translated from *Banyasz. Kohasz. Lapok, Kohasz.*; **107**: 170-176(1974). 25p. Dep. NTIS $3.50.

The X-ray diffraction determination of the dislocation density in shaped, polycrystalline metal is considered along with the practical problems of measurement. Methods are described based on etching and the use of an electron microscope, in addition to the measurements of electrical resistance, the coercive force, and stored energy. The X-ray diffraction method is particularly advantageous when a dislocation density higher than $10^{11}$ $cm^{-2}$ has to be measured.

**5324** (AEC-tr—7533/9, pp 35-40) **Moessbauer absorption by $^{57}Fe$ implanted into solids.** Sawicka, B.D. (Inst. of Nuclear Physics, Krakow); Sawicki, J.A. Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

The Moessbauer absorption by $^{57}Fe$ implanted into various materials is discussed on the basis of experimental data so far obtained.

**5325** **Recovery and recrystallization during high temperature deformation.** McQueen, H.J. (Concordia Univ., Montreal); Jonas, J.J. pp 393-493 of In Treatise on materials science and technology. VI. Arsenault, R.J. (ed.). New York; Academic Press Inc. (1975).

Microstructural changes in metals occurring during and after hot working are considered and their effects on mechanical properties of the worked material are described. Sections are included on recrystallization, recovery, and effects of deformation on mechanical properties. 136 references. (JRD)

**5326** **Electrolytic polishing of titanium, its alloys, and various other metals and alloys.** Coons, W.C.; Iosty, L.R. (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA). pp 193-202 of In Microstructural science. Vol. 4. Filer, E.W. (ed.). New York; Elsevier Publishing Co., Inc. (1976).

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

See CONF-750774—.

This paper describes new procedures employed in the electrolytic polishing of specimens of many metals and their alloys for optical microscopy evaluation of microstructures. The elemental metals successfully polished include titanium, zirconium, hafnium, molybdenum, nickel, cobalt, vanadium and rhenium. A basic electrolyte consisting of sulphuric acid, methyl alcohol, zinc chloride and aluminum chloride is utilized. The concentration of sulphuric acid is varied depending upon the metal that is to be polished. For instance, the electrolyte for titanium and its alloys consists of 10 ml sulphuric acid, 200 ml methyl alcohol, 5 g zinc chloride and 15 g aluminum chloride. For molybdenum, nickel and cobalt, the amount of sulphuric acid is increased to 30 ml and for vanadium and rhenium 50 ml of sulphuric acid is used. Many photomicrographs of microstructures are presented with a considerable number illustrating unusual microstructures associated with metallurgical phenomena.

**5327** **Microstructural effects of high temperature thermal treatment in Fe—Cr—Ni austenitic stainless steels.** Moorhead, A.J.; Canonico, D.A. (Oak Ridge National Lab., TN). pp 347-366 of In Microstructural science. Vol. 4. Filer, E.W. (ed.). New York; Elsevier Publishing Co., Inc. (1976).

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

See CONF-750774—.

A study was undertaken to determine the effects of various thermal treatments on the microstructure of eight experimental stainless steel alloys. Seven of the 50-lb (23-kg) consumable--electrode vacuum--melted heats were Fe—Cr—Ni ternaries that vary in composition from 10 percent Ni—19 percent Cr to 19 percent Ni—24 percent Cr, while the eighth was a quaternary containing 3.5 wt percent Mn. High-purity starting stock and careful melting procedures produced compositions with low residual element contents e.g., (in ppM), P, 5—15; C, 40—60; S, 40—55; H, 10—35; N, 20—100; and O, 100—350. The cast ingots were extruded at 1100°C to 1.5-in.-dia bar, portions of which were subsequently either forged and hot rolled to plate or swaged at room temperature to 9/32-in.-dia rod. Only portions of the swaged rod were used in the present thermal treatment study. 3/8-in. lengths of each heat were heat treated in vacuum for 1 h at each of the following temperatures: 900, 1000, 1050, 1100, 1150, 1200, and 1250°C. A transverse section of each specimen was prepared for metallographic examination and etched with 50 HCl—10 $HNO_3$ to reveal the general microstructure, and with boiling Murakami's reagent to reveal delta-ferrite. The grain size in each specimen was estimated by comparison with ASTM Standard Grain Size overlays. Additionally, DPH transverses were taken across each specimen, andthe amount of ferromagnetic phase (delta-ferrite and/or martensite) in each was determined by use of a Magne-Gage. 20 figs.

## MECHANICAL PROPERTIES

*REFER ALSO TO CITATION(S) 4578, 4821, 4839, 5007, 5094*

**5328** (CONF-750989—P2, pp II.64-II.71) **Foil specimens for the investigation of mechanical properties in ion simulation experiments.** Auer, J.; Saguees, A.A. (Institut fuer Festkoerperforschung der Kernforschungsanlage, Juelich, Ger.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

In many ion simulation experiments, heat dissipation and the moderate range of light ions impose an upper limit for the sample thickness. On the other hand, mechanical property investigations require a certain minimum sample thickness in order to minimize surface and grain size effects. In this work some factors which determine this lower limit are reported for "pure" stainless steel type 316. This material has the same basic composition as AISI 316 but contains only traces of impurities like C, Si, etc., thus eliminating the influence of precipitates by different heat treatments. Cylindrical "bulk" specimens (2 mm diam.) and foil specimens (thickness D between 30 and 100 $\mu m$) with grain sizes d between 1 and 45 $\mu m$ were prepared by a suitable thermomechanical treatment. Tensile tests at room temperature showed that the grain size dependence of the yield stress becomes slightly stronger for small grain sizes, however, the yield stresses are the same for bulk and foil specimens of the same grain size. The uniform elongation epsilon of the foil specimens (which is here practically equal to the total elongation) is generally only half the uniform elongation of the bulk specimens. For small grain sizes the ultimate tensile strength of foil specimens is only slightly lower than for bulk specimens, however, it drops to very low values if the grain size becomes comparable to the foil thickness (D less than 2 — 3d). Creep experiments on similar samples show a substantial decrease in creep rate with decreasing foil thickness probably caused by the increasing influence of surface effects.

**5329** (LBL—5423) **Structure and mechanical properties of Fe—Cr—Mo—C alloys with and without boron.** Chen, Y.L. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). May 1976. Contract W-7405-Eng-48. 123p. Dep. NTIS $5.50.

Thesis.

Nonconventional heat treatments were designed to improve the mechanical properties of these martensitic steels. Results show that the as-quenched structures of both steels consist mainly of dislocated martensite. In the boron-free steel, there are more lath boundary retained austenite films. The boron-treated steel shows higher strengths at all tempering temperatures but with lower Charpy V-notch impact energies. Both steels show tempered martensite embrittlement when tempered at 350°C for 1 hour. The properties above 500°C tempering are significantly different in the two steels. While the boron-free steel shows a continuous increase in toughness when tempered above 500°C, the boron-treated steel suffers a second drop in toughness at 600°C tempering. Transmission electron microscopy studies show that in the 600°C tempered boron-treated steel large, more or less continuous cementite films precipitate at the lath boundaries, which are probably responsible for the embrittlement. The differences in mechanical properties at tempering temperatures above 500°C are rationalized in terms of the effect of boron-vacancy interactions on the recovery and recrystallization behavior of these steels. Boron seems to impair room temperature impact toughness at low strength levels but not at high strength levels. By simple nonconventional heat treatments of the present alloys, martensitic steels may be produced with quite good strength-toughness properties which are much superior to those of existing commercial ultra-high strength steels. It has also been shown that the as-quenched martensitic steels need not be brittle and in fact very good combinations of strength and toughness can be obtained with as-quenched martensitic steels. 56 fig., 5 tables, 75 references. (DLC)

**5330** (SAND—76-8634) **High strain rate mechanical response of buttress-grooved tensile specimens which have undergone environmental exposure.** Weirick, L.J. (Sandia Labs., Livermore, Calif. (USA)). Jul 1976. Contract E(29-1)-789. 45p. (CONF-760540—15). Dep. NTIS $4.00.

From Conference on high density alloy penetrator materials; Charlottesville, Virginia, United States of America (USA) (24 May 1976).

The purpose of the corrosion compatibility program was to identify the effect of corrosion on the mechanical performance of the buttress-grooved section of the 105-mm penetrator, a section which must sustain a load during launch. It is important that the environment not deteriorate the mechanical integrity of these grooves during long-term storage. Both coated and uncoated test specimens which simulate both geometrical shape and residual stress patterns were exposed to corrosive environments of moist air, distilled water, and salt water. Some of these tests also incorporated the galvanic coupling caused by the aluminum sabot. After exposure to the corrosive environments, the specimens were pulled on a high strain rate tensile machine which simulated launch conditions. Results show that the galvanic coupling due to the aluminum sabot caused no deterioration of mechanical properties. Results do indicate that the coating applied caused a significant reduction in the fracture load. There was a dichotomy in the results as affected by the environment. Uncoated test specimens showed no change in fracture load with increasing severity of corrosion environment, whereas the coated specimens indicated a trend of decreasing load-bearing ability with increasing corrosion.

**5331** (SU—326P38X4) **Subgrain refinement strengthening. Fourth quarterly progress report, July 1, 1975—September 30, 1975.** Klundt, R.; Sherby, O.D. (Stanford Univ., Calif. (USA). Dept. of Materials Science and Engineering). 1976. Contract AT(04-3)-326. 9p. Dep. NTIS $3.50.

The effects of large strain deformation at 700 to 800°C on the development of subgrains in 26 Cr—1 Mo steel was investigated. Based on results it is postulated that the dislocations within the subgrain boundary take on a more perfect ordered array with strain; it is then suggested that a well ordered array may be a poor barrier to plastic flow at warm temperature (where dislocation climb is rate controlling) but is a good barrier at low temperature (where dislocations must break through the subgrain boundary barrier).

**5332** (SU—326P38X5) **Subgrain refinement strengthening. Annual report, October 1, 1974—September 30, 1975.** Klundt, R.; Monma, Y.; Walser, B.; Sherby, O.D. (Stanford Univ., Calif. (USA). Dept. of Materials Science and Engineering). 1976. Contract E(04-3)-326. 69p. Dep. NTIS $4.50.

Investigations were conducted to develop fine subgrains in selected ferritic and austenitic alloys as a possible means of enhancing the creep resistance of such materials. The model systems selected for testing during the report period include an austenitic stainless steel (type 304) and a ferritic stainless steel (26 chromium, 1 molybdenum). Results of tests indicate the strong effect that subgrain refinement may have on the high temperature properties of materials when subgrain strengthening dominates the deformation process. Since subgrain formation is a dominant structural feature of iron base alloys after warm deformation it is clearly worth-while to quantify the possible influence of subgrain size on the creep rate of austenitic and ferritic stainless steels. It was found that the flow stress, sigma, is a function of the subgrain size, lambda, following the relation sigma varies as $\text{lambda}^{-0.35}$. It was possible to predict that 304 stainless steel can be increased in strength by a factor of 2.7 over the normally expected strength at 650°C and epsilon = $10^{-10}s^{-1}$ (i.e., a one year rupture life) if stable subgrains 0.2 $\mu$m in size can be developed. It is postulated that the dislocations within the subgrain boundary in 26 Cr—1 Mo steel take on a more perfect ordered array with strain; it is then suggested that a well ordered array may be a poor barrier to plastic flow at warm temperature (where dislocation climb is rate controlling) but is a good barrier at low temperature (where dislocations must break through the subgrain boundary barrier).

**5333** (Y—1364) **Development of ductile tungsten alloys.** Googin, J.M.; Harper, W.L.; Neeley, A.C.; Phillips, L.R. (Oak Ridge Y-12 Plant, Tenn. (USA)). 3 Aug 1961. Contract W-7405-eng-26. 76p. Dep. NTIS $5.00.

Declassified 7 Sep 1976.

The fabrication of ductile tungsten alloys was investigated and their mechanical properties measured. Tungsten-nickel-iron alloys with tungsten contents of 93 percent or higher were studied most extensively. The influences of various processing parameters upon ductility are reported. Of those alloys which attained a density of approximately 18.00 g/cm³, the 95 percent W—3.5 percent Ni—1.5 percent Fe was found to be the most ductile, elongating 17.6 percent on the average and as much as 28 percent, and having average ultimate and yield strengths of 136,900 and 92,500 psi, respectively.

**5334** (Y/DA—6665) **Variables that affect mechanical properties of uranium—0.75 titanium alloys.** Koger, J.W.; Hemperly, V.C. (Oak Ridge Y-12 Plant, Tenn. (USA)). 12 May 1976. Contract W-7405-eng-26. 12p. (CONF-760540—10). Dep. NTIS $3.50.

From Conference on high density alloy penetrator materials; Charlottesville, Virginia, United States of America (USA) (24 May 1976).

Mechanical properties of the U—0.75 Ti alloy are affected by variables of aging temperature, aging time, melt temperature, melt time, double melting, working temperature, homogenization time and temperature, test atmosphere, humidity, plating, machining method, and the chemical levels of titanium, silicon, and iron in the alloy. 7 figures, 3 tables.

**5335** **Treatise on materials science and technology. Volume VI. Plastic deformation of materials.** Arsenault, R.J. (ed.). New York; Academic Press, Inc. (1975). 517p. $45.00.

Seven chapters are included in the book. A separate abstract was prepared for each of six chapters. The chapter for which no abstract was prepared is concerned with fatigue properties of polymers. (JRD)

**5336** **Cyclic deformation of metals and alloys.** Laird, C. (Univ. of Pennsylvania, Philadelphia). pp 101-162 of In Treatise on materials science and technology. VI. Arsenault, R.J. (ed.). New York; Academic Press, Inc. (1975).

Phenomena associated with rapid hardening or softening caused by cyclic straining in the early stages of fatigue life of metals and alloys are reviewed. The factors which control these phenomena are described and also the dislocation structures which are associated with them. In so far as the mechanisms of cyclic deformation are understood these too are described and a number of parallels between cyclic and unidirectional deformation are pointed out. A similar approach is then taken for materials which contain second phases for strength. Note that these studies apply to cycling at ambient temperatures or below. High-temperature cyclic deformation is beyond the scope of this review. An engineering method of predicting cyclic stress-strain response from tensile testing data is examined in the light of the fundamental knowledge described, and is shown to be severely limited. A method of improving such prediction by introducing additional microstructural information which is readily available is suggested. 117 references. (JRD)

**5337** **High-temperature creep.** Mukherjee, A.K. (Univ. of California, Davis). pp 163-224 of In Treatise on materials science and technology. VI. Arsenault, R.J. (ed.). New York; Academic Press, Inc. (1975).

The status of experimental knowledge on high-temperature diffusion-controlled creep of metals and alloys is evaluated. The effects of independent variables of stress and temperature on creep rates and the influence of crystal structure, modulus of elasticity, stacking fault energy, and grain size on creep are examined. The major substructural changes associated with high temperature creep are reviewed and the theoretical implications of aspects relative to the validity of proposed high-temperature creep mechanisms are summarized. 112 references. (JRD)

**5338** **Review topics in superplasticity.** Alden, T.H. (Univ. of British Columbia, Vancouver). pp 225-266 of In Treatise on materials science and technology. VI. Arsenault, R.J. (ed.). New York; Academic Press, Inc. (1975).

The effects of grain refinement, grain growth, creep, and temperature on superplasticity in metals and alloys are reviewed. Sections are included on production of fine grains, microstructural changes during deformation, rate-sensitive deformation, and creep. 54 references. (JRD)

**5339** **Low temperature of deformation of bcc metals and their solid-solution alloys.** Arsenault, R.J. (Univ. of Maryland, College Park). pp 1-99 of In Treatise on materials science and technology. VI. Arsenault, R.J. (ed.). New York; Academic Press Inc. (1975).

A review of information is presented concerning the deformation characteristics of bcc metals and alloys. Sections are included on asymmetry of slip and yielding, dislocation configurations, core structure of a screw dislocation, analysis of dislocation dynamics, interstitial alloys, H alloys, substitutional alloys, radiation effects, and superconductivity. 173 references. (JRD)

**5340** **Relationship of microstructure to fracture topography in orthopedic alloys.** Gilbertson, L.N. (Zimmer USA, Inc., Warsaw, IN). pp 159-167 of In Microstructural science. Vol. 4. Filer, E.W. (ed.). New York; Elsevier Publishing Co., Inc. (1976).

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

See CONF-750774—.

Two major alloys used for orthopedic implants are 316L stainless steel and a cast cobalt—chromium—molybdenum alloy similar to Haynes Stellite 21. Another alloy that is just being introduced is Ti—6Al—4V. All three of these alloys are used in different conditions with different microstructures. Standard specimens with typical microstructures encountered in orthopedic applications were loaded to fracture in both overload and fatigue modes. Different rates of loading were also used in some cases. The fracture surfaces of these standard samples were analyzed in the Scanning Electron Microscope. An attempt was made to relate the fracture behavior, as evidenced by the fracture typography, to the microstructure of the alloy as revealed by metallography.

**5341 Fracture of orthopedic implants.** White, W.E.; Postlethwaite, J.; Le May, L. (Univ. of Saskatchewan, Saskatoon). pp 145-158 of In Microstructural science. Vol. 4. Filer, E.W. (ed.). New York; Elsevier Publishing Co., Inc. (1976).

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

See CONF-750774—.

Based on the fractographic and metallographic analysis of several clinical, orthopaedic, stainless steel implant failures and on the results from corrosion studies on AISI Type 316 stainless steel, fracture models have been developed to define more explicitly fracture initiation and subsequent crack propagation in these devices. Results show that environmentally induced failure may proceed via corrosion fatigue, stress-corrosion cracking and/or hydrogen embrittlement. Furthermore, small changes in the environment may be all that is necessary to cause a change from one fracture mode to another, even during the propagation of a single crack. 8 figs, 37 references.

## PHYSICAL PROPERTIES

*REFER ALSO TO CITATION(S) 4397, 4491, 5355, 5431, 5440, 5856, 6392*

**5342** (BNL—21689) **Line shape of magnetic excitations in singlet-ground-state systems.** Bak, P. (Brookhaven National Lab., Upton, N.Y. (USA)). Aug 1976. Contract E((30-1)-16. 7p. (CONF-760922—12). Dep. NTIS $3.50.

From International conference on magnetism; Amsterdam, Netherlands (6 Sep 1976).

The excitation spectrum in a paramagnetic singlet doublet system is calculated using a diagrammatic expansion technique, and the theoretical predictions are compared with experiments on praseodymium. The theory gives an accurate description of the dramatic temperature dependence of the energies and lineshapes for the exciton modes.

**5343** (BNL—21690) **Hyperfine fields at impurity sites in iron.** Watson, R.E.; Bennett, L.H. (Brookhaven National Lab., Upton, N.Y. (USA); National Bureau of Standards, Washington, D.C. (USA). Inst. for Materials Research). 1976. Contract E(30-1)-16. 7p. (CONF-760922—10). Dep. NTIS $3.50.

From International conference on magnetism; Amsterdam, Netherlands (6 Sep 1976).

Controversy has recently revived concerning the correlation of hyperfine fields at impurity atom sites in ferromagnetic iron with atomic volume or with valence. Using a scheme to normalize to the free atom hyperfine field, the correlations of volume, valence, and electronegativity with new normalized values are inspected.

**5344** (CONF-750989—P2, pp II.234-II.249) **Helium release from type 304 stainless steel.** Cost, J.R.; Hickman, R.G.; Holt, J.B.; Borg, R.J. (Univ. of California, Livermore). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

Helium in very low concentration (less than 1 atomic parts per billion) has been introduced into type 304 stainless steel by radioactive decay of dissolved tritium. The release of this helium during subsequent annealing has then been monitored with a high sensitivity mass spectrometric gas analyzer. With isochronal annealing, helium is released in two temperature ranges, first near 300°C and then between 800°C and the melting point. The latter release is interpreted as being due to helium gas bubbles. The release near 300°C has been studied isothermally between 150°C and 300°C, and has been analyzed in terms of two stages of exponential decay. The fast and slow release stages have relaxation times near $10^2$ and $10^3$ seconds, respectively, and the fast release accounts for roughly 0.85 of the total release at low temperature. From an analysis of the release kinetics, it is concluded that volume diffusion is the controlling mechanism for the outgassing.

**5345** (CONF-750989—P4, pp IV.274-IV.289) **Experimental measurements of the permeation of hydrogen isotopes in lithium filled niobium cells.** Goodall, D.H.J.; McCracken, G.M.; Austin, G.E. (Culham Lab., Abingdon, Eng.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Lithium filled niobium cells have been heated in vacua at temperatures in the range 300 to 900°C. By measuring the flow of deuterium into the cell it has been possible to make estimates of the rate of permeation of deuterium in the niobium wall. After initial fast diffusion into the capsule the rate of permeation becomes very much slower than that determined by diffusion in the bulk niobium indicating that a second, slower, rate process is involved. Measurements of the rate of deuterium permeation out of the cell have been made for a number of different cell geometries and a range of temperatures. The results indicate that the slow rate process, which is dominant at low concentrations, is the desorption step from the metal to the gas phase.

**5346** (CONF-750989—P4, pp IV.317-IV.328) **Tritium permeation through steam generator materials.** Bell, J.T.; Redman, J.D.; Strehlow, R.A.; Smith, F.J. (Oak Ridge National Lab., TN). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

A model for tritium permeation through metals with oxide coatings is developed. The development includes considerations of permeation through clean non-oxidized metals, through metals with perfect oxide coatings, and through metals that have defective oxide coatings. The mathematical model includes a film quality factor which represents the quality of the film with respect to covering the surface of the metal. A set of curves of tritium flux vs tritium driving pressure calculated with this model shows how a film and the film quality factor will affect the pressure dependence of permeation through a coated metal.

**5347** (CONF-750989—P4, pp IV.361-IV.378) **Permeation of hydrogen at low pressures through stainless steel and implications for tritium control in fusion reactor systems.** Axtmann, R.C.; Johnson, E.F.; Kuehler, C.W. (Princeton Univ., NJ). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

New experimental data on the permeation of hydrogen through stainless steel indicate that at driving pressures below $10^{-2}$ torr, the permeation rate is linearly dependent on the driving pressure. A possible consequence is that the permeation rates of hydrogenic species in fusion reactor systems might be much lower than those reported in contemporary conceptual design studies which assume that the rates are dependent on the square root of the driving pressure. The important implications of these low permeation rates are: (1) tritium losses to the environment may be more dependent on ordinary leaks from equipment than on permeation to the steam cycle; (2) recovery of tritium from breeding blankets via permeation windows may be impracticable; and (3) recovery of tritium from breeding blankets not dependent on permeation windows may be simplified by the possibility of operating at much higher average tritium concentrations in the blanket and cooling systems.

**5348** (CONF-750989—P4, pp IV.401-IV.413) **Permeation of tritium and deuterium through 21-6-9 stainless steel.** Swansiger, W.A. (Sandia Labs., Livermore, CA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Tritium and deuterium permeabilities were measured for annealed 21 Cr-6 Ni-9 Mn stainless steel at hydrogen isotope pressures of 1.3 to 13.3 kPa and sample temperatures of 95 to 430°C. The effects of two surface treatments were compared. The tritium permeability of a sample which had been sputter-cleaned then sputter-coated with 200 A of palladium is given by: phi = 9.9 x $10^{-3}$ exp (—15760 cal/$mol^{-1}$/RT) cc (STP)$T_s/cm^{-1}/sec^{-1}/atm^{-1/2}$.

The tritium permeability of a sample which had been passivated using a common nitric acid—Nitradd treatment is given by: phi = 4.5 exp (—24500 cal/mol$^{-1}$/RT) cc (STP)T$_s$/cm$^{-1}$/sec$^{-1}$/atm$^{-1/2}$. This treatment, which is often used to clean stainless steel prior to welding, creates a thin, stable oxide film. Deuterium permeabilities were determined for two samples which had received the same treatments as the tritium permeation samples. The activation energies for permeation were the same (within experimental error) as for the corresponding tritium samples.

**5349** (CONF-750989—P4, pp IV.414-IV.422) **Permeation of tritium through aluminium in the temperature range of 25 to 250°C.** Ihle, H.; Kurz, U.; Stoecklin, G. (Institut fuer Chemie der Kernforschungsanlage, Juelich, Ger.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Permeation of tritium through aluminium is expected to be very low at ambient temperatures due to the high endothermic heat of solution of hydrogen in this metal. In order to obtain experimental data for its use as tritium-barrier, the permeation of $T_2$ at about 0.2 atm pressure through a 1 mm wall of an Al-capsule with an area of 100 cm$^2$ was measured in the temperature range of 25 to 250°C. Gas flow counting was used for detection. In the temperature range from 150 to 250°C the permeation rate appears to be controlled by bulk diffusion, since the measured heat of permeation, Q = 29,400 kcal/mol, agrees well with the heat of permeation of $H_2$ through Al calculated from known diffusion and solubility data, obtained from measurements close to the melting point of Al. Between 25 and approximately equal to 150°C the observed permeation of tritium through Al was higher than expected from calculations, possibly due to grain boundary diffusion; however, it is still many orders of magnitude lower than that through most common metals.

**5350** (CONF-750989—P4, pp IV.117-IV.132) **Hydrogen effects in aluminum alloys.** Louthan, M.R. Jr.; Caskey, G.R. Jr.; Dexter, A.H. (Savannah River Lab., Aiken, SC). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The permeability of six commercial aluminum alloys to deuterium and tritium was determined by several techniques. Surface films inhibited permeation under most conditions; however, contact with lithium deuteride during the tests minimized the surface effects. Under these conditions phi/sub $D_2$/ = 1.9 x $10^{-2}$ exp (—22,400/RT) cc (NTP)atm/sup $-1/_2$/ s$^{-1}$cm$^{-1}$. The six alloys were also tested before, during, and after exposure to high pressure hydrogen, and no hydrogen-induced effects on the tensile properties were observed.

**5351** (CONF-750989—P4, pp IV.203-IV.225) **Characteristics of SORB-AC non-evaporable getter cartridges and their potential use in fusion reactors.** Barosi, A.; Giorgi, T.A.; Rosai, L. (SAES, Milan). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The possible use of non-evaporable getter pumps and SORB-AC cartridges in the problems related to the storage and cycling of the hydrogen isotopes, deuterium and tritium, as well as those connected with nuclear fusion reactor experiments is reported. The structural characteristics of traditional and non-magnetic getter pumps and cartridges are described. Their use and characteristics in the high and ultra-high vacuum range are reviewed. The characterization is extended to the pressure range $10^{-2}$ to $10^{-4}$ torr for hydrogen and its isotopes so as to cover the application fields of present interest. Typical applications are illustrated as examples of the ability of these pumps to store, purify and recycle hydrogen and its isotopes. The operating conditions of the pumps in these different applications are linked to the reversible sorption capacity of hydrogen which depends on the hydrogen equilibrium pressure in the gas phase and the temperature of the getter material. The influence of gaseous impurities, for example CO, on the gettering characteristics for hydrogen are also considered.

**5352** (COO—3429-27) **Thermal, structural, and magnetic studies of metals and intermetallic compounds. Final report.** Wallace, W.E.; Craig, R.S.; Rao, V.U.S. (Pittsburgh Univ., Pa. (USA). Dept. of Chemistry). 15 Aug 1976. Contract E(11-1)-3429. 28p. Dep. NTIS $4.00.

The powerful magnetism of certain intermetallics, e.g., $SmCo_5$, has been established to originate with the powerful magnetic anisotropy of $SmCo_5$, not its large magnetization. The anisotropy is, in turn, a crystal field effect. The crystal field interaction has been elucidated by the method of quantum mechanics. Studies of the systems $RFe_2$, $RFe_3$, $RCo_5$, and $R_2Co_7$ (R = a rare earth, Y or Th) reveals them to be important for hydrogen storage. In addition, important effects associated with hydrogenation of metals have been found—great enhancement of magnetization of certain systems (e.g., $ErFe_2$) and substantial increase in superconducting transition temperatures (e.g., Zr/sub .5/H/sub .5/V$_2$). Results of studies suggest that the surfaces of rare earth intermetallics are atypical. The spectrum of properties exhibited by the rare earth intermetallics suggests their utility in the efficient capture and storage of solar energy and the use of it for powering a vehicle. These aspects of the systems warrant further attention.

**5353** **Investigation of the dynamic processes occurring in superconducting windings.** Altov, V.A.; Kremlev, M.G.; Sytchev, V.V.; Zenkevitch, V.B. (Inst. for High Temperature, Moscow). *Adv. Cryog. Eng.*; **19**: 186-192(1974).

Dynamic processes of propagation or contraction of a normal zone in composite superconductors are investigated in order to supplement results of previous investigations on thermal equilibrium of a composite superconductor. The results are given and evaluated.

**5354** **Low temperature heat capacity of $LaRu_2$ by a.c. technique.** Viswanathan, R.; Pande, C.S. (Brookhaven National Lab., Upton, N.Y. (USA)); Lawson, A.C. *J. Phys. Chem. Solids;* **37**: No. 3, 341-343(1976).

The low temperature heat capacity data of a small bulk sample of $LaRu_2$ show that the structural transformation occurring at Tsub(m) approcimately 29.5 K is rather spread out. The electronic heat capacity coefficient, $\gamma$, and the Debye temperature, thetasub(D), are found to be respectively 8.5 mJ/g.atom K$^2$ and 164 K. The multiple anomalies below Tsub(m) and Tsub(c) (4.45 K) are discussed.

**5355** **Emissivity and structure of anodized beryllium.** Zhorov, G.A.; Al'movskii, R.M.; Urazbaev, M.I.; Gornyi, D.S. (Moscow). *High Temp. (USSR) (Engl. Transl.);* **14**: No. 1, 37-40(Jan 1976).

Results are presented on the emissivity of anodized beryllium between 400 and 1000 degreeK in relation to the thickness and structure of the oxide layer; for thicknesses up to 92 $\mu$, the integral normal degree of blackness varies from 0.08 to 0.88. A stable emissivity is found for anodized beryllium bearing an oxide film annealed in air, which consists of the equilibrium oxide BeO. Metastable structures in the oxide film alter the emissivity of anodized beryllium considerably. An amorphous oxide layer reduces the integral normal degree of blackness relative to equilibrium BeO, whereas a hydrated film deficient in oxygen increases the value. The temperature ranges for stability in the metastable structures have been determined for heating in air. (AIP)

**5356** **Specific heat of tungsten at high temperatures.** Zinov'ev, O.S.; Lebedev, S.V. (High-Temperature Institute, Academy of Sciences of the USSR). *High Temp. (USSR) (Engl. Transl.);* **14**: No. 1, 73-75(Jan 1976).

The specific heat of tungsten in the temperature range 2300—3600 degreeK was measured from the cooling of a tungsten wire in vacuum. Jones and Langmuir's tables [1], which connect the current flowing through the wire in steady-state conditions with its temperature and radiated power, were used. Cooling of the wire after pulse heating was also investigated. The results are compared with published data. (AIP)

**5357** **High-temperature emissivity and resistivity of MVR-27-VP2 heat-resisting alloy.** Peletskii, V.E.; Druzhinin, V.P. (High-Temperature Institute, Academy of Sciences of the USSR). *High Temp. (USSR) (Engl. Transl.);* **14**: No. 1, 191-192(Jan 1976).

The alloy MUR-26-UP2 was prepared by vacuum arc melting. The emissivity was measured in the range 1200—2400 degreeK, while the resistivity was determined in the range 300—200 degreeK. (AIP)

**5358** **Anomalous behavior of phonon spectrum near 2.5-order phase transition.** Galkin, A.A.; Svistunov, V.M.; Revenko, Y.F.; Mostovoi, V.M.; Belogolovskii, M.A. (Donets Physico-technical Institute, Ukrainian Academy of Sciences). *JETP Lett. (USSR) (Engl. Transl.);* **23**: No. 4, 1-3(20 Feb 1976).

By the method of electron tunneling we have found a nonlinear behavior of the phonon frequencies of indium fused with tin. We discussed the possible causes of these anomalies, and also their influence on the critical temperature of the superconducting transition. (AIP)

**5359 Nondestructive tests prove cryogenic alloys' mettle.** Anon. *Iron Age;* 217: No. 8, 49-50(23 Feb 1976).

Transporting liquefied natural gas at -260°F demands safety in vessels containing the fuel at 1/600th of its natural volume. This has elevated nondestructive testing to a height normally reserved for nuclear and aerospace activities. This article features Kaiser Aluminum and Chemical Corp's NDT methods used in fabricating shipboard LNG containment vessels. Aluminum appears superior to steel in this application but since it is a new one, all material and welds are nondestructively inspected.

**5360 High-temperature transport properties of cerium, praseodymium, neodymium, and europium.** Zinov'ev, V.E.; Gel'd, P.V.; Sokolov, A.L. (S. M. Kirov Ural Polytechnic Institute, Sverdlovsk). *Sov. Phys. - Solid State (Engl. Transl.);* 18: No. 6, 764-766(May 1976).

Results are given of investigations of the temperature dependences of the electrical resistivity (290—900degreeK), thermal diffusivity (550—1100degreeK), and thermal conductivity of cerium, praseodymium, neodymium, and europium. The temperature dependences of the transport coefficients have anomalies associated with phase transitions. The mechanisms of electron scattering in these rare earth metals are discussed and it is shown that the magnetic contribution to the scattering is appreciably larger than was hitherto assumed. (AIP)

**5361 Dependence of the magnetic anisotropy energy of the Dy/sub x/Gd/sub 1-x/ system on its composition.** Kazakov, A.A. (A. M. Gor'kii Ural State University, Sverdlovsk). *Sov. Phys. - Solid State (Engl. Transl.);* 18: No. 6, 825-826(May 1976).

It is proposed that the experimental results on the measurement of the anisotorpy coefficient of Dy/sub x/Gd/sub 1-x/ can be explained by allowing for a possible difference between the effective charges of the Gd and Dy ions.(AIP)

**5362 Influence of conducting coatings on T/sub c/ of superconducting lead films.** Orlov, A.F.; Milai, A.K.; Dmitriev, V.P. (Institute of Metallurgy, Academy of Sciences of the USSR, Moscow). *Sov. Phys. - Solid State (Engl. Transl.);* 18: No. 6, 854-855(May 1976).

The dependence of the transition temperature of superconducting lead films on the thickness of coatings is investigated. The coatings considered are Zn, Bi, Mo, Si, Ge, C, Se, and PbTe.(AIP)

**5363 Mossbauer study of the lattice properties of the system $V_3Ga_1$/sub -//sub x/Sn/sub x/ .** Kimball, C.W.; Weber, L.W.; Fradin, F.Y. (Northern Illinois University, DeKalb, Illinois 60115). *Phys. Rev., B;* 14: No. 7, 2769-2777(1 Oct 1976).

The temperature dependence of the $^{119}$Sn Mossbauer shift and the relative recoil-free fraction has been measured in the A-15 pseudobinary compounds $V_3Ga_1$/sub -//sub x/Sn/sub x/ (x = 0.9, 0.5, 0.1). A two-Debye model for the phonon spectra describes the Sn vibrational motion, $< v^2 >$ and $< x^2 >$. For $V_3Ga_6$/sub ./$_6$Sn$_0$ /sub ./$_1$ a deviation of the thermal shift from Debye behavior is shown to be due to lattice softening; that is, phonon mode shifting is observed for the Ga-rich high-T/sub c/ compound. Comparison with heat-capacity results indicates that the vibrational motion of the vanadium atom also softens at low temperature. Moreover, a consideration of the concentration dependence of the Sn and Ga phonon contribution to the mass enhancement $\lambda$ suggests that the vanadium site controls the dependence of $\lambda$, and hence T/sub c/, on concentration. (AIP)

**5364 Electrical resistivity and magnetic susceptibility of $\beta$-cerium from 2 to 300 K .** Burgardt, P.; Gschneidner, K.A. Jr.; Koskenmaki, D.C.; Finnemore, D.K.; Moorman, J.O.; Legvold, S.; Stassis, C.; Vyrostek, T.A. (Ames Laboratory—United States Energy Research and Development Administration and Departments of Physics and Materials Science and Engineering, Iowa State University, Ames, Iowa 50011). *Phys. Rev., B;* 14: No. 7, 2995-3006(1 Oct 1976).

The electrical resistivity and magnetic susceptibility of allotropically pure $\beta$-Ce and $\gamma$-Ce and some two-phase ($\alpha + \beta$ or $\beta + \gamma$) samples, which were predominantly $\beta$-Ce, were measured from 2 to 300 K. Because $\beta$-Ce transforms to $\alpha$-Ce between 15 and 50 K, several unusual experimental techniques were used to obtain reliable data. Our results show that the electrical resistivity of $\beta$-Ce remains unusually large, > 50 $\mu\Omega$ cm down to 40 K and below this temperature it drops an order of magnitude. The magnetic-susceptibility data show that $\beta$-Ce obeys the Curie-Weiss law down to near its Neel temperature, ~ 12.5 K. Low-field susceptibility data, < 800 Oe, show a Neel temperature at 12.5 K and that the magnetic susceptibility near the ordering temperatures decreases with increasing field. X-ray metallographic data indicate that when $\beta$-Ce transforms to $\alpha$-Ce the initial growth occurs at the surface and grows inward. The unusual temperature dependence of the electrical resistivity of $\beta$-Ce could not be explained by several existing models (band-spin fluctuation or crystalline field) which have been used to explain large increases in the resistivity for other materials. However, a recently developed model based on Kondo scattering which is quenched by magnetic ordering appears to account for the observed results. (AIP)

## CORROSION AND EROSION

*REFER ALSO TO CITATION(S) 4397, 4440, 4452, 4483, 4484, 4512, 4573, 4596, 4786, 4795, 4821, 4869, 4885, 4918, 5104, 5330*

**5365 (AD-A—012528) Modification and control of oxide structure on metals and alloys: Phase V. Final technical report, 2 Mar 1974—2 Mar 1975.** Svedberg, R.C. (Westinghouse Electric Corp., Pittsburgh, Pa. (USA). Astronuclear Lab.). May 1974. Contracts N62269-74-C-0289; N00019-70-C-0148. 81p. (WANL-MFR—75-001). NTIS $4.75.

See also report dated Feb 1973, AD—785261.

Indepth analyses of over 50 x-ray diffraction patterns of oxides grown on niobium based oxidation resistant alloys are presented. The oxides analyzed were grown in air on niobium based alloys containing Cr, Ti, Al, Co, Ni, and/or Fe in various amounts and compositions at temperatures between 800 and 1200°C. The analysis of the x-ray diffraction data has shown the oxidation protection of these alloys to be associated with a rutile (tetragonal) oxide of the form MNbO4 where M + Al, Cr, Fe, and/or Co. In most of the oxidation resistant alloys, a spinel related structure such as CoAl2O4(CoO-Al2O3) was detected. Various powder metallurgy and thermomechanical processing techniques were used in attempts to fabricate useful alloys with the compositions 73.4Nb-15Fe-11.6Al and 80Nb-5.6Co-13.9Al. Both alloy compositions were processed by various powder metallurgy techniques from elemental, intermetallic, and arc-melted alloy powders. Powder compacts were densified by a combination of cold isostatic pressing and sintering, high impact rate extrusion or conventional extrusion. (GRA)

**5366 (CONF-750989—P4, pp IV.98-IV.116) Tritium effects in austenitic steels.** Louthan, M.R. Jr.; Caskey, G.R. Jr.; Rawl, D.E. Jr.; Krapp, C.W. (Savannah River Lab., Aiken, SC). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Conditions of tritium absorption and helium build-in simulating those expected in long service in a fusion reactor had little effect on the ductility of Types 304L and 309S austenitic stainless steels. Long (25 to 50 years) exposures of prospective component and structural materials to reactor conditions were simulated in short-duration tests by matching tritium concentration gradients in test samples at time of testing with those expected in reactor service, without regard to time required to obtain desired tritium concentrations. Tritium effects on ductility of 304L samples were not significantly different from those caused by protium or deuterium. Surface finish and metallurgical condition can influence the tritium concentration gradient by increasing diffusivity and solubility and by trapping tritium at extraordinary sites. Build-in of $^3$He in concentrations as great as 0.14 cc/cc of metal caused no significant ductility losses except when tensile tests or postexposure anneals were conducted at temperatures high enough to cause helium agglomeration. The lack of significant He-induced effects at near ambient temperatures agrees with results of ion bombardment studies made by other investigators.

**5367 Behavior of austenitic, Nb-stabilized weld metal deposits after heat treatment, with particular emphasis on applications for internal structures of nuclear reactors.** Schabereiter, H. *Z. Schweisstech.;* 65: No. 3, 63-79(1975). (In German).

The effect of diverse alloying elements, such as chromium, nickel, niobium, and nitrogen on the corrosion behavior and susceptibility to embrittlement of stabilized, austenitic weld metal deposit has been investigated after annealing at 550-950°C. Basically coated rod electrodes have been used in the investigations which covered five different experimental alloys. Based on the results obtained, it has been possible to develop special stabilized, austenitic welding filler metals such as coated electrodes and submerged-arc and gas-shielded arc filler wires which fully meet the high requirements imposed on nuclear reactor construction.

**5368 Gas quality control and analysis.** Jones, H.G. *Am. Gas Assoc., Oper. Sect., Proc.;* D37-D41(1975).

Relationship between gas quality control and the mitigation of internal corrosion in gas pipeline systems is discussed. Gas quality in terms of acceptable standards for internal corrosion con-

trol and guidelines for enforcement and methods of analysis of the various components which contribute to the corrosiveness of gaseous mixtures are analyzed and presented in tabular and graphical form. 6 refs.

**5369 New methods and developments for corrosion control.** Haught, J.W. *Am. Gas Assoc., Oper. Sect., Proc.*; D53-D54(1975).

Various devices for protection are described based on factory specifications.

**5370 Topographical, microstructural, and chemical effects of simulated high heat flux on the corrosion of Type 316 stainless steel in flowing sodium.** Bagnall, C.; Shiels, S.A.; Orbon, S.J. (Westinghouse Electric Corp., Madison, PA). pp 23-35 of In Microstructural science. Vol. 4. Filer, E.W. (ed.). New York; Elsevier Publishing Co., Inc. (1976).

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

See CONF-750774—.

Earlier work, performed in sodium test facilities around the world, have produced corrosion data for Type 306 SS which has been used to estimate metal loss rates from the core of a LMFBR. Practical difficulties precluded evaluation of the influence on corrosion of irradiation, a high heat flux and the high axial temperature gradient the latter produces. Downstream effects in isothermal regions were, however, documented in some tests. This paper presents recent results of corrosion experiments conducted in a test facility designed to produce a temperature rise in the fluid equivalent to a heat flux in the primary heater of about 0.5 x $10^6$ Btu/(h-ft$^2$). The axial temperature gradient was such that the sodium temperature was increased over a distance of three feet from 820F at the inlet, to 1360F at the outlet. The secondary ion mass spectrometer, electron probe microanalyzer, scanning electron microscope, and optical microscope were used individually to characterize the various compositional, topographical, and structural changes that occurred in the stainless steel as a result of the sodium exposure. Several important effects attributable to the high axial temperature gradient were noted.

## RADIATION EFFECTS

*REFER ALSO TO CITATION(S) 5328, 5339, 6382, 6383, 6384, 6385, 6387, 6388, 6390*

**5371** (CONF-750989—P1, pp I.17-I.72) **Radiation damage: the second most serious obstacle to commercialization of fusion power.** Kulcinski, G.L. (Univ. of Wisconsin, Madison). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The uniqueness of radiation damage associated with 14 MeV neutrons is discussed in relation to total displacements per atom (dpa), dpa rate, gas production rate, gas to dpa ratio, and solid transmutation products. Comparisons are made with both light water and fast reactors to illustrate that it will be very difficult to use the latter facilities to provide information about high power fusion reactors. The one exception to this statement pertains to 316 SS in thermal reactors where the proper helium gas generation rate is achieved. Examination of the displacement and transmutation damage with respect to the dimensional, mechanical and physical properties of metals reveals that there is very little, if any pertinent experimental data available. Providing this data will require a massive and time consuming test program that could spread over a decade or more. Considering the shear number of radiation damage problems and their magnitude leads one to believe that their solution will be a major barrier to the commercialization of fusion power, second only to those problems associated with plasma physics.

**5372** (CONF-750989—P1, pp I.73-I.92) **Ion bombardment simulation: a review related to fusion radiation damage.** Brimhall, J.L. (Battelle-Pacific Northwest Labs., Richland, WA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

Prime emphasis is given to reviewing the ion bombardment data on the refractory metals molybdenum, niobium and vanadium which have been proposed for use in advanced fusion devices. The temperature and dose dependence of the void parameters are correlated among these metals. The effect of helium and hydrogen gas on the void parameters is also included. The similarities and differences of the response of these materials to high dose, high temperature radiation damage are evaluated. Comparisons are made with results obtained from stainless steel and nickel base alloys. The ion bombardment data is then compared and correlated, as far as possible, with existing neutron data on the refractory metals. The theoretically calculated damage state produced by neutrons and ions is also briefly discussed and compared to experimental data wherever possible. The advantages and limitations of ion simulation in relation to fusion radiation damage are finally summarized.

**5373** (CONF-750989—P1, pp I.93-I.105) **Void swelling of Nb, Nb—1 at.% Zr, and Nb—0.5 at.% O induced by $^{58}Ni^+$ bombardment.** Loomis, B.A.; Taylor, A.; Gerber, S.B. (Argonne National Lab., IL). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The void swelling of Nb, Nb-1 at. percent Zr, and Nb—0.5 at. percent 0 during 3.2-MeV $^{58}Ni^+$ irradiation at temperatures between 600 and 1150°C has been determined. The void swelling of Nb and Nb-1 at. percent Zr determined from transmission-electron microscopy observations shows a "double peak" at 825 +- 25°C and 1000 +- 25°C. The presence of 0.5 at. percent 0 in Nb results in a significantly reduced void swelling of Nb at all irradiation temperatures. Oxygen impurity in Nb was shown to be necessary for the formation of an ordered void array. The ordered void array is responsible for the reduced void swelling of Nb. A Ti coating on Nb significantly affects the void size and void distribution.

**5374** (CONF-750989—P1, pp I.106-I.121) **Influence of neutron irradiation temperature on the void characteristics of niobium and niobium—1% zirconium alloy.** Jang, H.; Moteff, J. (Univ. of Cincinnati). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

Voids in Nb and Nb-1 wt. percent Zr alloy irradiated to a fast neutron fluence of approximately 1 x $10^{22}$ n cm$^{-2}$ (E greater than 1 MeV) at six different temperatures between 430 and 1050°C have been investigated. Transmission electron microscopy observations revealed the presence of voids in both Nb and Nb-1 Zr at all six irradiation temperatures. The void number density and size of the niobium specimens appeared unaffected by irradiation temperatures between 430 and 700°C, but the void number density decreased and the size increased at the higher temperatures. Other observations regarding Nb were that ordered voids were observed at 800°C with the lattice parameter of 685 A, and the maximum void swelling was approximately 0.5 percent which occurred at 1050°C. In contrast, the Nb-1 percent Zr alloy specimens showed larger voids and lower number density than the corresponding Nb specimens. The void swelling of Nb-1 Zr reached the maximum of approximately 2 percent at 800°C. At the irradiation temperatures of 430, 580, and 1050°C the voids were observed only in small localized areas resulting in negligible void swelling.

**5375** (CONF-750989—P1, pp I.122-I.129) **High temperature irradiation damage structures in fast reactor irradiated nioblum and vanadium alloys.** Bartlett A.F.; Evans, J.H.; Eyre, B.L.; Terry, E.A.; Williams, T.M. (AERE, Harwell, Eng.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The void swelling behavior of commercial purity niobium and vanadium samples has been examined after irradiation to a dose of 3.6 x $10^{22}$ n/cm$^2$ in the Dounreay Fast Reactor at 450, 550 and 600°C. In addition the irradiation programme included samples of Niobium 5 percent Zirconium, Niobium 10 percent Zirconium, zone refined vanadium and V-15 percent Cr-5 percent Ti. The irradiated void and dislocation structures were examined using transmission electron microscopy. The most important general result was that in the alloys examined the void swelling was negligible. In the purer specimens there was a marked effect of temperature on void concentration and size but the overall effect on void swelling was small.

**5376** (CONF-750989—P1, pp I.130-I.149) **Ion simulation study of void formation in high purity vanadium.** Weber, W.J.; Kulcinski, G.L.; Lott, R.G.; Wilkes, P.; Smith, H.V. (Univ. of Wisconsin, Madison). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

Ion simulation techniques were used to study the characteristics of void formation in high purity vanadium bombarded with 18 MeV Cu ions. The samples were vacuum annealed at 1050°C (less than $5 \times 10^{-8}$ Torr) and irradiated at temperatures from 600 to 750°C (less than $1 \times 10^{-9}$ Torr) to damage levels ranging from 1 to 5 dpa. The damage rate was $3 \times 10^{-4}$ dpa/sec in the analyzed region, approximately one micron from the front surface. The damage structure consisted of voids (less than $5 \times 10^{14}$ $cm^{-3}$) and precipitates at low densities, dislocation loops, and dislocation networks. The precipitates were analyzed to be face-centered cubic vanadium-carbide (VC) by Auger and electron diffraction analysis. The degree of precipitation was found to depend on sample surface preparation. A description of void morphology, precipitate morphology, grain boundary denuding, and the temperature dependence of void size, shape, density and subsequent swelling is given.

**5377** (CONF-750989—P1, pp I.150-I.157) **Dose dependence of void swelling in vanadium irradiated with self-ions.** Agarwal, S.C.; Taylor, A. (Argonne National Lab., IL). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The void-swelling behavior of HPV irradiated with 3-MeV $^{51}V^{+}$ ions to damage levels between 1 and 55 dpa at temperatures between 650 and 700°C has been investigated by means of transmission-electron microscopy. The results suggest that swelling increases with dose initially, attains a maximum value at some intermediate dose, and then decreases during additional irradiation. The decrease in swelling at higher doses is believed to be due to irradiation-induced precipitates.

**5378** (CONF-750989—P1, pp I.191-I.206) **14 MeV neutron damage in silver and gold.** Lyles, R.L.; Merkle, K.L. (Argonne National Lab., IL). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

Displacement damage due to 14-MeV neutrons predominantly takes place in the form of rather energetic displacement cascades. The vacancy clusters that are directly formed in the depleted zones are observed by transmission electron microscopy in 14 MeV neutron bombarded gold and silver. The number densities and structures of cascades will be compared quantitatively with theoretical predictions and results from cascade studies using self-ion bombardment. The splitting into subcascades will be demonstrated and its importance to 14 MeV neutron damage will be discussed.

**5379** (CONF-750989—P1, pp I.207-I.229) **HVEM quantitative stereoscopy through the full damage range of an ion-bombarded Fe—Ni—Cr alloy.** Diamond, S.; Baron, I.M.; Bleiberg, M.L.; Bajaj, R.; Chickering, R.W. (Westinghouse Advanced Reactors Div., Madison, PA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The swelling of a Ni-ion irradiated Fe-25 percent Ni-15 percent Cr alloy has been investigated employing high voltage (1 MeV) electron microscopy. Helium pre-injected samples were irradiated to a maximum dose of 92 dpa with 3.5 MeV $^{60}Ni^{+}$ ions at 600, 650, 700 and 750°C. By means of quantitative stereoscopy throughout the full range of ion damage, the void morphology, swelling and dislocation morphology as functions of the distance from the ion-entry surface of the foil were obtained. The dose also varied as a function of depth and, with this technique, swelling as a function of dose was determined from a single sample at each temperature. Swelling, void concentration, and void size varied with irradiation temperature with the maximum swelling of 7.4 percent occurring at 700°C. Several distinct dislocation configurations could be distinguished progressing inward from the ion-entry surface. The observations suggest that nucleation and growth of voids are related to dislocation densities and possibly to dislocation structure. The swelling-dose relationships were analyzed using a linear expression for each apparent swelling regime and the results interpreted in terms of the Brailsford and Bullough statistical rate theory. Two distinct steady-state swelling regimes exist at each irradiation temperature and the difference in the rates is attributed to the different kinetic development of the dislocation structure and densities in the two stages.

**5380** (CONF-750989—P1, pp I.240-I.258) **Influence of pre-injected helium on void swelling in ion-irradiated stainless steels.** Mazey, D.J.; Nelson, R.S. (AERE, Harwell, Eng.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

High energy implantation of helium is used extensively to promote void formation in ion bombardment experiments designed to simulate irradiation damage effects in materials of potential use in reactors. However, the concurrent effects of radiation damage and helium production in the reactor interact to produce a complex behavior which is difficult to simulate precisely. Such effects are expected to be more significant in a fusion reactor where helium concentrations could build up to approximately $10^{-3}$ atom/atom. The likely effects of pre-implantation of helium at ambient and elevated temperature are discussed and related to the ideal simulation experiment in which helium injection and heavy-ion irradiation are carried out concurrently. Experimental TEM results are given for annealed AISI 316 stainless steel which had been injected with helium concentrations from $10^{-6}$ to $10^{-3}$ atom/atom at ambient temperature. These show that an interstitial loop structure evolves during annealing between 550°C and 700°C and that the retained interstitial atom fraction in the loops is the same as the injected helium concentration. This indicates a strong effect of helium on evolved structure and retained point-defects. Comparison of void swelling at 40 dpa in AISI 321 steel after pre-injection of $10^{-6}$, $10^{-5}$ and $10^{-4}$ atom/atom helium at 30°C and 600°C showed that swelling is much higher in the material implanted with $10^{-4}$ He at 600°C. Small helium bubbles were resolved in 316 and 321 steel after implantation of $10^{-5}$ and $10^{-4}$ atom/atom helium at 600°C and the numbers of voids which formed during subsequent nickel ion irradiation to 40 dpa at 600°C were found to be similar to the initial bubble concentration. The effects on void formation of the various defect structures which result from helium implantation are discussed.

**5381** (CONF-750989—P1, pp I.259-I.288) **Swelling and microstructural changes in type 316 stainless steel irradiated under simulated CTR conditions.** Maziasz, P.J.; Wiffen, F.W.; Bloom, E.E. (Oak Ridge National Lab., TN). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

Tensile specimens of type 316 stainless steel were irradiated in the High Flux Isotope Reactor (HFIR) to displacement damage levels of 42-60 dpa (displacements/atom) and helium contents of 3000-4300 at. ppm at temperatures from 380 to 680°C. The samples were irradiated in both the annealed condition (1 hr at 1050°C) and the 20 percent cold worked condition. The microstructures of these samples were examined by transmission electron microscopy (TEM). The results were compared with specimens of the same heat of steel irradiated in EBR-II to approximately the same conditions with the exception of helium content, which was approximately 15 at. ppm. Swelling in annealed and cold worked samples with high helium content was approximately constant with temperature from 380 to 550°C and increased rapidly from 550 to 680°C. Swelling in cold worked samples was less than in the annealed samples for all temperatures except 680°C. Swelling was larger at all temperatures for samples containing large helium concentrations than for the same material with small helium concentrations. Recrystallization at 600°C destroyed the cold work swelling resistance. Cold work increased the cavity concentrations, decreased the cavity sizes, and reduced the swelling, compared with annealed material containing equivalent high helium concentrations. Swelling was greatly increased at irradiation temperatures above 600°C in both the annealed and cold worked samples; the increase was due to the formation of very large cavities at the grain boundaries. Calculations to compare the amount of helium measured in the samples with the amount necessary to stabilize equilibrium bubbles have shown most of the cavities to be equilibrium helium bubbles.

**5382** (CONF-750989—P1, pp I.289-I.296) **Nucleation of voids in a neutron environment.** Mayer, R.M. (Atomic Energy Boards, Pretoria); Brown, L.M. Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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A model of void nucleation in a neutron environment is formulated based on chemical rate theory. The resulting set of first order differential equations is numerically integrated using a computer. The swelling due to voids in nickel, copper, alpha iron and molybdenum is then compared with experiment.

**5383** (CONF-750989—P1, pp I.297-I.311) **Suppression of void formation in neutron irradiated TZM.** Bentley, J. (Univ. of Birmingham, Eng.); Eyre, B.L.; Loretto, M.H. Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

A TEM study of the damage structures in Mo (2 purities) and TZM alloy neutron irradiated in the temperature range 330°C to 850°C to fluences of 1 to 3 x $10^{20}$ fission n . $cm^{-2}$ has revealed that at the lower irradiation temperatures the structures in all three materials consist of a fine distribution of voids plus a dislocation component of loops and networks. The structures generally coarsen with increasing irradiation temperature but in TZM this tendency is reversed at irradiation temperatures of 750 and 850°C where the damage structure consists of a high concentration (approximately 3 x $10^{15}$ $cm^{-3}$) of dislocation loops (approximately 200 A diameter) with an almost complete absence of voids and thus a very low value of swelling. Contrast experiments have shown that these loops are, remarkably, vacancy in nature. A number of observations—the presence of vacancy loops as the major component of the damage structure in the alloy only, the stability and shrinkage behavior of the loops during postirradiation annealing and TEM observations which suggest both slight modifications of the loop strain fields and an increased value of the loop glide stress—all imply a strong interaction between impurities and the dislocation loops. The observations can be understood in terms of segregation of oversize alloying elements to the dislocation cores. The very low value of swelling is an important result for CTR technology since it occurs in a candidate material for the first wall at typical proposed operating temperatures.

**5384** (CONF-750989—P1, pp I.312-I.322) **Damage structure in neutron irradiated TZM.** Pard, A.G.; Garr, K.R. (Atomics International, Canoga Park, CA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

Transmission electron microscopy (TEM) has been used to study the damage structure of TZM after irradiation in EBR-II to fluences of 3.8 x $10^{26}$ and 8 x $10^{26}$ $n/m^2$ (E greater than 0.1 MeV) at temperatures of 500°C and 600°C. The damage structure consists of individual defect clusters, rafted defect clusters, dislocation loops and line segments, and voids. Swelling was negligible in all cases. The nature and disposition of the damage structure as a function of irradiation temperature and fluence is discussed.

**5385** (CONF-750989—P1, pp I.323-I.336) **Kinetic stability against void coarsening in molybdenum.** Simonen, E.P.; Brimhall, J.L. (Battelle-Pacific Northwest Labs., Richland, WA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The measured rate of increase of void size in molybdenum with annealing time is found to be slower than expected from the Wagner analysis of diffusion-controlled coarsening. The Wagner theory of surface-reaction-control is also compared with ripening data. The determined surface kinetic parameters are compared with vacancy diffusivities and are found to be not unrealistic. Furthermore, a measured decrease in void volume during annealing indicates that total void volume is not conserved. These observations support the conclusion that void coarsening is influenced by more than one rate controlling mechanism. A numerical solution to the void annealing problem is obtained and the specific role of volume diffusion, surface kinetics, and annealing of vacancies to sinks other than voids is calculated.

**5386** (CONF-750989—P1, pp I.337-I.351) **Effect of the free surface on void formation in ion bombardment molybdenum.** Bradley, E.R.; Brimhall, J.L. (Battelle-Pacific Northwest Labs., Richland, WA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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Heavy ion bombardment is currently being considered as a technique to simulate neutron damage in CTR components, especially the first wall structure. The use of heavy ion bombardment as a neutron simulation technique has been criticized due to the damage zone being near a free surface (i.e., less than or equal to 1 micron for 5 MeV $Ni^{++}$ ions in molybdenum). The purpose of the present investigation was to examine the microstructure of ion bombarded molybdenum at and below the bombarded surface utilizing transmission electron microscopy to determine the influence of the free surface on void formation. Single crystal molybdenum discs were bombarded at 1000° +- 25°C with 5 MeV $Ni^{++}$ ions at surface dose rates of 3 x $10^{-4}$, 1.8 x $10^{-3}$, and 8 x $10^{-2}$ dpa/sec. The void size and density were determined as a function of depth below the bombarded surfaces. Voids were observed within 100 A of the bombarded surfaces and no significant indications of surface-related effects were observed. The variations in void size and density are discussed in terms of the total dose and dose rate at the various regions of examination and the results compared with existing ion bombardment and neutron irradiation data.

**5387** (CONF-750989—P1, pp I.362-I.381) **Collision cascades in iron and niobium.** Beeler, J.R. Jr.; Beeler, M.F.; Parks, C.V. (North Carolina State Univ., Raleigh). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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Defect production by collision cascades in fcc iron and niobium was studied using a computer experiment approach. Cascades with energies up to 975 keV and 594 keV were studied for iron and niobium, respectively. In the case of iron, the primary defect state produced directly by each cascade was subjected to short-term annealing (STA) simulation at 566°C. Recipes for the numbers of free defects, defect clusters, microvoids and interstitial loops after STA, as functions of cascade energy, were constructed from the annealing computer experiment results. In the case of niobium, the primary defect state is described. For a given PKA energy, the displacement production in niobium was about 18 percent smaller than that in iron. The cascade size in niobium was about the same as that in iron up to 100 keV.

**5388** (CONF-750989—P1, pp I.382-I.394) **Proton simulation of 14 MeV neutron damage and low temperature recovery of 16 Mev proton irradiated iron.** Thompson, D.A.; Walker, R.S.; Robinson, J.E.; Omar, A.M.; Campbell, A.B. (McMaster Univ., Hamilton, Ont.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The Total Damage Energy deposited into iron bombarded with 14.3 MeV and 17.0 MeV protons, and 14 MeV neutrons has been computed using scattering theory. The results suggest the validity of using high energy protons to simulate 14 MeV neutron damage. Measurements are reported of resistivity change and recovery in $\alpha$-iron bombarded at 68°K with 16 MeV protons. The results are compared to fast fission neutron data and the calculated damage energies.

**5389** (CONF-750989—P1, pp I.417-I.436) **Analysis of radiation damage in fusion-simulation neutron spectra.** Parkin, D.M.; Goland, A.N. (Los Alamos Scientific Lab., NM). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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Various parameters which are relevant to an understanding of radiation effects in metals have been evaluated utilizing available neutron spectrum information for several existing sources, e.g., EBRII, HFIR, and LAMPF, as well as the hypothetical spectrum at a fusion reactor first wall, and measured Li(d,n) spectra. Recoil energy distributions were calculated for several metals including Al, Cu, and Nb. The recoil energy range was divided into groups, and the fraction of recoils occurring in each energy group was compared with the fraction of the damage energy contributed by that group. From this comparison it was possible to conclude that the significant recoil range differs by about an order of magnitude between fission and fusion sources. The analysis further confirms that basic defect production characteristics depend upon the neutron spectrum, and that integral calculations of radiation-effect parameters do not provide a complete description of the dependence. This is equally true for cmparisons between fusion-related spectra or fission-reactor spectra independently. Four recoil-depen-

dent parameter functions which describe different aspects of radiation damage were used in the calculations. The relative effectiveness of neutron sources was found to depend upon the choice of parameter function. Fission-reactor spectra comparisons are relatively insensitive to the parameter functions used whereas spectra with an appreciable component of high-energy neutrons are much more sensitive.

**5390** (CONF-750989—P1, pp I.474-I.490) **Stress effects in ion bombardment experiments.** Garner, F.A.; Wire, G.L.; Gilbert, E.R. (Hanford Engineering Development Lab., Richland, WA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

Ion bombardment is employed to simulate the neutron damage that will occur in fusion reactor structural materials. These experiments usually involve specimens whose thickness is large compared to the ion range. The correct interpretation of such experiments requires inclusion of the impact of swelling-induced stresses, which arise from the rigidity of the non-swelling region beyond the ion range. An initial low level of swelling is accommodated by elastic compression of the voided region, giving rise to anisotropic stresses whose deviatoric components lead to plastic deformation by various irradiation creep mechanisms. Swelling generates the stresses which lead to creep, which in turn limits the magnitude of stress. The hydrostatic stress along the ion range eventually saturates at a level which reduces the swelling rate from the anticipated stress-free value. The swelling is fully anisotropic, two-thirds of the deformation having been diverted from directions normal to the ion beam. Crystalline anisotropy further modifies the relative rates of creep processes, and radiation-hardening of the lattice imposes an additional fluence dependence. Stress reversal at denuded zones leads to second-order stress effects. The use of step height measurements allows observation and measurement of these phenomena. Estimates of the stress levels and swelling rates can be made using swelling and creep coupling coefficients derived from fission reactor data. A significant reduction in swelling rate is predicted by this analysis.

**5391** (CONF-750989—P1, pp I.491-I.518) **Influence of displacement gradients on the interpretation of charged particle simulation experiments.** Garner, F.A.; Guthrie, G.L. (Hanford Engineering Development Lab., Richland, WA). Mar 1976.

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Neutron flux and spectrum gradients are negligible within a single grain of structural materials in fusion reactors. In charged particle simulation, however, substantial gradients exist in the flux of displaced atoms (dpa) along the ion path, which is typically several microns or less in length. In interpretation of such experiments, one must account for the influence of variables that are atypical of the simulated environment. Experimental and modeling studies show that dpa gradients lead to gradients in microstructure, which in turn modify the effect of diffusion on the effective growth environment of voids and other defects. For some ions, these effects are overwhelmed by a phenomenon designated the "internal temperature shift." Although the physical temperature is relatively invariant along the ion path, the temperature regime of swelling shifts as the displacement rate changes. The swelling vs. depth profile is altered substantially from that expected from the dpa profile, and the type of modification is dependent on the relation of the irradiation temperature to the peak swelling temperature at the mean displacement flux. Swelling profiles for a variety of simulations were analyzed and found to include the influence of surface denuded zones, incubation effects, diffusion, swelling-generated stresses and internal temperature shifts. The impact of the latter imposes restrictions on the interpretation of step height measurements and full range intercorrelations for high energy ions.

**5392** (CONF-750989—P1, pp I.519-I.531) **Dimensional stability of stainless steel as affected by compositional transmutations.** Bates, J.F.; Schiffgens, J.O.; Paxton, M.M. (Hanford Engineering Development Lab., Richland, WA). Mar 1976.

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One of the major uncertainties involved in the implementation of 316 stainless steel as the material for the first wall of a Controlled Thermonuclear Reactor (CTR) is the question of solid transmutation effects. While the magnitude of these compositional changes can be estimated with reasonable certainty, the physical and metallurgical material perturbations associated with such changes are still largely unknown. The purpose of this report is to present property change data, relative to specific transmutational composition changes, developed from fission reactor irradiations and corresponding unirradiated control tests which can impact CTR design. The effects of composition on the in-reactor behavior of 316 stainless steel are currently being studied by both irradiation-induced swelling experiments conducted in EBR-II and out-of-reactor control studies. These experiments are based on alloy variations from a nominal 316 base steel. In several series of alloys, the composition of a single element and that of iron was varied. Series being studied include variations in C, N, P, S, B, Mn, Cu, Si, Mo, Co, Cr and Ni. The results indicate that the behavior of 316 stainless steel in a first wall CTR application would undergo no serious detrimental changes due to solid compositional transmutations.

**5393** (CONF-750989—P2, pp II.84-II.117) **Ion-simulated irradiation-induced creep of nickel.** Hendrick, P.L. (Naval Research Lab., Washington, DC); Pieper, A.G.; Michel, D.J.; Surratt, R.E. Mar 1976.

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An experimental apparatus has been designed and constructed at the Naval Research Laboratory to measure the ion-simulated irradiation-induced creep of uniaxial tensile specimens bombarded by ions from the NRL Sector-Focusing Cyclotron. High purity nickel tensile specimens were bombarded with 22 MeV deuterons and 70 MeV alpha particles at displacement rates ranging from 13 to 30 x $10^{-6}$ displacements per atom per second. The experimental technique which was developed during the course of this investigation allowed creep rate to be measured with an on-line computer while temperature, stress, and flux were maintained at the desired level. Irradiations were conducted at 224°C (435°F) and at stresses ranging from 170 to 345 MPa (24,700 to 50,100 psi). The results obtained demonstrated that charged particle irradiations can successfully be used to simulate irradiation-induced creep in bulk material. Preliminary data is in agreement with a linear flux dependency and suggest a linear to squared dependence on stress over the range investigated. A comparison of deuteron and alpha particle irradiation test results suggests a lower irradiation effect per displaced atom on irradiation-induced creep rate during alpha particle irradiations. A climb-controlled creep model is in agreement with the irradiation-induced creep observed.

**5394** (CONF-750989—P2, pp II.118-II.121) **Apparatus to study irradiation-induced creep with a cyclotron.** Herschbach, K.; Mueller, K. (Kernforschungszentrum Karlsruhe, Ger.). Mar 1976.

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An apparatus is described which allows accurate measurements of length changes of specimens irradiated on a cyclotron while a uniaxial stress is applied. Basic to the design is a "chimney" which establishes a strong convection in the liquid Na, which serves as a heater bath. Deuterons of high enough energy (E greater than or equal to 50 MeV) can penetrate into the creep capsule and—with a careful layout of the capsule—irradiation-induced creep can be studied. The precautions necessary to achieve a good resolution are given in some detail.

**5395** (CONF-750989—P2, pp II.122-II.140) **Effect of irradiation temperature on radiation-anneal hardening in vanadium.** Shiraishi, K.; Fukaya, K.; Katano, Y. (Japan Atomic Energy Research Inst., Tokai). Mar 1976.

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Vanadium samples were irradiated to a fast neutron fluence of 8.0 x $10^{19}$ to 1.2 x $10^{20}$ n/cm$^2$ (En greater than or equal to 1 MeV) at temperatures in the range from 70 to 600°C, and the radiation hardening measured at room temperature was investigated in terms of microstructure. The radiation-anneal hardening phenomenon was observed in samples irradiated at 200 and 460°C, whereas the radiation hardening in the sample irradiated at 70°C recovered monotonically with increasing anneal temperature. The density of defect clusters visible in the electron microscope decreased with increase in post-irradiation annealing temperature.

The hardening induced by post-irradiation annealing is considered to be due to small interstitial impurity clusters. The sample irradiated at 70°C to a fluence of 1.2 x $10^{21}$ n/cm² had good ductility on tensile test at temperatures of 450°C and above. The sample irradiated at a temperature of 200°C or below to a fluence beyond 8 x $10^{19}$ n/cm² exhibited plastic instability or a little work hardening on deformation at room temperature. The irradiation embrittlement was not recovered by post-irradiation annealing at temperatures up to 450°C.

**5396** (CONF-750989—P2, pp II.141-II.158) **Correlation of the hot-hardness with the tensile strength of neutron irradiated molybdenum.** Moteff, J. (Univ. of Cincinnati); Schmidt, C.G.; Wiffen, F.W. Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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The elevated temperature ultimate tensile strength of recrystallized and of neutron irradiated molybdenum is shown to correlate very well with the corresponding hot-hardness data through the relationship sigma/sub u/ = (H/3) (n/0.217)/sup n/ where H and n are the hardness values and strain hardening exponent respectively at the given temperatures. It is proposed that the hot-hardness tester be used as a strength microprobe in the preliminary evaluation of the mechanical properties of advanced alloys and of other materials generally available in limited quantities, such as irradiated specimens.

**5397** (CONF-750989—P2, pp II.159-II.171) **15 MeV neutron damage in Cu and Nb.** Roberto, J.B.; Narayan, J.; Saltmarsh, M.J. (Oak Ridge National Lab., TN). Mar 1976.

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High energy neutron damage in Cu and Nb irradiated with approximately 15 MeV neutrons at the Oak Ridge Isochronous Cyclotron was investigated. The neutrons were generated by bombarding a thick Be target with 40 MeV deuterons resulting in a high energy neutron spectrum broadly peaked at 15 MeV. Single crystals of Cu and Nb were irradiated at room temperature to fluences of approximately 2 x $10^{17}$ n/cm². The resulting loop-type defect clusters in the crystals were characterized using x-ray diffuse scattering and transmission electron microscopy. The cluster size distributions were found to be generally similar to those characteristic of fission neutron irradiations in these materials and no multiple clusters or sub-clusters were observed. Additional comparisons with fission reactor irradiations in Cu and Nb indicate that the retained displacement damage in these crystals is greater for the high energy neutrons than for an equivalent fluence of fission neutrons. This result is consistent with detailed damage energy calculations for the Be(d,n) neutron spectrum.

**5398** (CONF-750989—P2, pp II.172-II.208) **DT fusion neutron radiation strengthening of copper and niobium.** Mitchell, J.B.; Van Konynenburg, R.A.; Parkin, D.M.; Echer, C.J. (Univ. of California, Livermore). Mar 1976.

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The initial results of a comparative study of the radiation strengthening and damage structures produced in Cu and Nb by D-T fusion and fission reactor neutrons are described. The radiation strengthening produced by a given fluence of fusion neutrons above about $10^{17}$ n/cm² is equal to that produced by a fluence of fission reactor neutrons (E greater than 0.1 MeV) ten times as great. This difference is about twice as large as would be expected if the strengthening scaled with damage energy or dpa. Initial transmission electron microscopy observations of the damage structures in fusion and fission reactor neutron irradiated copper indicate that the same type of primary structural defects, vacancy and interstitial point defect clusters and small dislocation loops with a/3 [111] and a/2 [110] Burgers vectors, are produced in both cases. The difference in the radiation strengthening produced by fusion and fission reactor neutrons in Cu appears to result from a substantially greater rate of accumulation of damage, in the form of point defect clusters, during irradiation with fusion neutrons than during irradiation with fission reactor neutrons plus a significant difference in the size and spatial distributions of the damage clusters.

**5399** (CONF-750989—P2, pp II.209-II.233) **Combined effects of displacement damage and high gas content in aluminum.** Farrell, K.; Houston, J.T. (Oak Ridge National Lab., TN). Mar 1976.

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A solid solution alloy of 2300 at. ppM of $^6$Li isotope in aluminum was neutron irradiated at about 0.36 T/sub m/ in high, fast and thermal fluxes producing a damage level of 2 to 3 dpa and simultaneously inducing a gas content of about 2200 at. ppM each of helium and tritium from burnup of $^6$Li. The gases significantly increased the nucleation of structural defects but did not change the degree of swelling; cavity concentrations were increased approximately 1000-fold, cavity sizes were decreased approximately 10-fold and there was approximately 10-fold increase in the concentrations of dislocations. Also, large cavities were developed on grain boundaries. The cavities were consistent with their being gas-filled bubbles. The refinement of damage structure by the gases caused a considerable increase in radiation hardening. Bend tests at 77 and 296°K revealed severe embrittlement and intergranular fracture. Comparison with data from material irradiated to produce comparable gas levels but relatively little displacement damage indicates that premature intergranular failure is much enhanced by the presence of a defect-hardened matrix. Postirradiation annealing tests showed the cavity and dislocation structures to have high resistance to annealing. Annealing also encouraged the development of a secondary population of large cavities believed to be associated with migration and precipitation of tritium.

**5400** (CONF-750989—P2, pp II.250-II.279) **Observations of helium bubble formation in 316 stainless steel implanted by alpha bombardment.** Smidt, F.A. Jr.; Pieper, A.G. (Naval Research Lab., Washington, DC). Mar 1976.

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Helium produced by transmutation reactions in the first wall of fusion reactors is expected to affect ductility and swelling. The migration of He during annealing of foil specimens of 316 stainless steel implanted with 20 to 60 ppM He at less than 200°C was studied to characterize He behavior under these conditions using transmission electron microscopy to characterize microstructures and the temperature of He bubble formation and bubble migration rates. Bubbles were observed after one-hour anneals at temperatures from 800 to 1100°C (the highest temperature examined) with negligible loss of He from the foils. Strong interactions between He bubbles and dislocations and grain boundaries were apparent. Comparison of the data with published results on neutron data and with theory suggests He migration is accelerated under a radiation flux.

**5401** (CONF-750989—P2, pp II.280-II.288) **Helium generation in copper by 14.8-MeV neutrons.** Holt, J.B.; Hosmer, D.W.; Van Konynenburg, R.A. (Univ. of California, Livermore). Mar 1976.

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High purity copper foils were irradiated with 14.8-MeV neutrons from the rotating target neutron source facility at LLL. The average energy of the neutrons was 14.75 +- 0.1 MeV, and the average fluence was 7.0 x $10^{16}$ n/cm². After irradiation each foil was heated to the melting point and the released helium was measured by a mass spectrometer of special design. Isochronal heating was carried out on several samples to establish the type and temperature of maximum release. Calculated cross sections from the literature for the (eta,$\alpha$) and (eta, eta'$\alpha$) nuclear reactions were used, and the predicted amount of helium was consistently about 0.5 of that actually measured. Because there is very little data on helium generation in metals irradiated with high energy neutrons, these results are important and will be related to potential CTR materials.

**5402** (CONF-750989—P2, pp II.289-II.306) **Influence of implanted helium on swelling behavior and mechanical properties of vanadium and V-alloys.** Ehrlich, K.; Kaletta, D. (Kernforschungszentrum, Karlsruhe, Ger.). Mar 1976.

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The influence of helium implantation on the swelling behavior and ductility in Vanadium and V-Ti alloys has been investigated by transmission electron microscopy and tensile testing. V and V-20 wt. percent Ti has been implanted with He-ions of low energy (240 keV) at irradiation temperatures between 450 and 700°C to fluences ranging from $2.5 \times 10^{14}$ to $5 \times 10^{17}$ ions/cm², which corresponds to peak concentrations of 125 and 250,000 at. ppM He respectively. The correlated ion-induced displacement damage is $1.1 \times 10^{-2}$ to 22 dpa. For comparison, in the first wall of a CTR about 10,000 ppM He will be generated via $(n,\alpha)$-reactions in V after a 10-year exposure. In pure V the threshold for bubble formation (d greater than or equal to 40 A) is $1 \times 10^{17}$ ions/cm² at 500°C; it decreases markedly with increasing irradiation temperature ($7 \times 10^{14}$ $He^+/cm^2$ at 600°C e.g.). The mean diameters increase hyperlinear with temperature and approximately linear with dose. The strong effect of temperature on the mean diameter can be explained by surface-diffusion controlled coalescence mechanisms. Generally two different growth processes are observed. The first one can be connected to vacancy trapping and the second one to coalescence. The observed maximum swelling is about 8 percent at 625°C. Additions of Ti reduce the concentration of bubbles and their distributions, but have no essential effect on the amount of swelling. Thus in this experiment swelling is mainly due to helium rather than to the displacement damage produced during the implantation. Pure vanadium tensile specimens were homogeneously implanted with 100 MeV He-ions up to 10 ppM helium between 200 and 300°C and tested between 750 and 950°C. No influence upon ductility or yield strength was found in agreement with earlier results on a V-3Ti-1Si alloy.

**5403** (CONF-750989—P2, pp II.307-II.330) **Effects of helium implanted by tritium decay on the high temperature mechanical properties of niobium.** Atteridge, D.G.; Charlot, L.A.; Johnson, A.B. Jr.; Remark, J.F.; Westerman, R.E. (Battelle-Pacific Northwest Labs., Richland, WA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

Helium-induced mechanical property degradation is one of the major material problems which must be assessed in predicting the lifetime of CTR first-wall structures. The effects of helium on the high-temperature short-time tensile properties of commercial purity niobium are being determined as a first step towards attaining a better understanding of inert gas/metal matrix interactions on mechanical properties. Helium concentrations from 30 to 500 at. ppM were implanted in the niobium matrix by tritium decay. The tritium was introduced into the matrix by a gas-charging technique and then removed after a sufficient decay time at room temperature for the helium concentrations to build up to the desired values. Subsequent tensile tests at 1020°C, utilizing buttonhead specimens of 0.41 cm gage diameter, revealed a decrease in uniform and total elongation with increasing helium content, accompanied by a helium-induced grain-boundary-decohesion failure mechanism. Microstructures and fracture surfaces are being investigated optically and by SEM and TEM; results of these studies are presented.

**5404** (CONF-750989—P2, pp II.331-II.343) **Mechanical behavior of Nb—1% Zr implanted with He at various temperatures.** Saguees, A.A.; Auer, J. (Institut fuer Festkoerperforschung der Kernforschungsanlage, Juelich, Ger.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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Nb-1 percent Zr polycrystalline foils of commercial purity were He-implanted at 50 and 600°C by a cyclotron $\alpha$-particle beam of variable energy to homogeneous concentrations in the $10^{-6}$ to $10^{-4}$ at. range. Tensile tests were made after implantation at a $10^{-4}$ $s^{-1}$ strain rate and temperatures from 20 to 800°C. The material implanted at 50°C exhibited radiation damage effects that annealed out when tested at the higher temperatures. In the whole temperature range the mode of foil fracture is transgranular and its characteristics appear unaffected by He concentrations of up to 80 at. ppM even when the foils are annealed under stress at temperatures between 650 and 1000°C prior to the tensile test. The material implanted at 600°C presents some reduction in ductility but still shows transgranular fracture. T.E.M. samples were prepared from the tensile specimens and from implanted material subjected to anneal under stress at up to 1300°C, and preliminary examinations reveal no features that can be identified with He segregation. Helium release measurements are discussed together with the T.E.M. results in terms of He distribution during implantation and posttreatment.

**5405** (CONF-750989—P2, pp II.344-II.361) **Creep and tensile properties of helium injected Nb—1% Zr.** Wiffen, F.W. (Oak Ridge National Lab., TN). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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Specimens of commercial purity Nb-1 percent Zr were helium doped by cyclotron $\alpha$-bombardment near room temperature to gas contents near 2 and 20 at. ppM He, corresponding to helium production in a CTR first wall during approximately one month and one year of operation at 1 MW/m² neutronic wall loading. These specimens were tensile and creep tested to evaluate the effect of helium, in the absence of other components of CTR radiation effects, on the mechanical properties. Tensile tests at 1000 and 1200°C show no significant effect of either helium level on the strength or elongation values. Creep-rupture tests at the same temperatures on Nb-1 percent Zr showed rupture elongations somewhat reduced in the helium injected samples but the dependence on helium content and on test temperature does not fit the usual effect of helium on elevated temperature ductility. It is concluded that in the absence of displacement damage this alloy is resistant to elevated-temperature embrittlement for helium contents up to 20 at. ppM. The resistance to embrittlement results from the precipitation of helium on a submicroscopic level and from the alloy's inherent resistance to grain boundary separation.

**5406** (CONF-750989—P2, pp II.362-II.371) **Study of He distributions in niobium by means of (n,p) reactions.** Biersack, J.P.; Fink, D. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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Helium will be introduced into fusion reactor first wall materials as low energy ions from the plasma, as neutron knock-ons from the coolant, and also from $(n,\alpha)$ reactions in the bulk. Direct observation of He which is distributed inside a metal is extremely difficult, and few attempts of detecting He profiles have been successful so far [Blewer using RBS in thin metal foils; Picraux et al, and Behrisch et al using the $^3He(d,p)^4He$ reaction]. In short, detailed studies of He in metals are still lacking, despite considerable practical and theoretical interest. The thermal neutron induced reaction $^3He$ (n,p)T of cross section 5000 barn which can be applied for detecting He profiles as well as He lattice locations is used. An advantage over other methods is seen in the facts that thermal neutrons cause practically no displacements of He or lattice atoms prior to detection, and that there is less background and higher sensitivity than in RBS or (d,p) detection. The method is applied for measuring depth profiles of He in Nb after implantation and after subsequent thermal anneals. A comparison with theoretical predictions yields the following results: (i) Mean ranges of 70 to 300 keV $He^+$ in Nb agree with theory after increasing the k value of Lindhard and Scharff. (ii) The width of the range distributions is slightly higher, the skewness is much lower than predicted. (iii) Upon anneal, implanted He does not diffuse, but is detrapped with an activation energy of 1.4 eV which does not correspond to He atoms bound to single vacancies.

**5407** (CONF-750989—P2, pp II.372-II.386) **Helium embrittlement of CTR materials simulated by ions implantation and hot isostatic pressing of metal powders.** Fleischer, L.R.; Spitznagel, J.A.; Choyke, W.J. (Westinghouse Research Labs., Pittsburgh). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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Helium embrittlement is currently considered a limitation on the lifetimes of CTR structures exposed to high energy neutrons. The phenomenon has been observed in fast fission reactor irradiated materials and has been studied in helium ion bombarded foil samples. In this study, helium ions were implanted in stainless steel and refractory metal alloy powder particles. The 150 keV ion energies used require particle size distributions with mean particle diameters of about 3 $\mu$m to get a suitably homogeneous initial distribution of helium atoms. The helium implanted powders were consolidated by hot isostatic pressing; the helium remained in solid solution. Subsequent thermomechanical processing permitted

the preparation of tensile specimens with controlled helium bubble distributions. In general, grain boundary migration concentrated helium bubbles on the boundaries, while conditions favoring stationary boundaries allowed intragranular bubble nucleation on dislocations. It remains to be seen whether the distributions available through these processes are representative of those that will be generated in situ by (n,$\alpha$) reactions in CTR neutron spectra. Specimens for bulk properties measurements prepared in this way are most suitable for study of helium embrittlement as an isolated effect. Many of the constraints encountered in other sample preparation methods are mitigated.

**5408** (CONF-750989—P2, pp II.387-II.402) **Radiation damage by $^{252}$Cf fission fragments and alpha particles.** Gould, T.H. Jr.; McDonell, W.R. (Savannah River Lab., Aiken, SC). Mar 1976.

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Rates of atom displacement and helium injection in materials exposed to $^{252}$Cf fission fragments and alpha particles were calculated to establish the potential for use of $^{252}$Cf sources for radiation damage studies. Maximum displacement rates of about $10^{-6}$ dpa/s at the surface of typical targets exposed to a $^{252}$Cf fission fragment source were comparable to those experienced by materials in a fast breeder reactor or in a controlled thermonuclear reactor (CTR) first wall, though much lower than the displacement rates achieved using particle accelerators. Helium was concurrently accumulated at a rate of $3 \times 10^{-4}$ atom ppM/s at the target surface, yielding a He/displacement ratio $10^3$ times that produced in the fast breeder reactor materials, but only about 20 times that produced in the CTR materials. These comparisons suggest that $^{252}$Cf fission fragment sources may find useful applications in studies of effects of high-He content on radiation damage in CTR materials.

**5409** (CONF-750989—P2, pp II.403-II.421) **Radiation damage in CTR magnet components.** Ullmaier, H. (Institut fuer Festkoerperforschung der Kernforschungsanlage, Juelich, Ger.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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Data are reviewed (already existing or to be acquired) which should allow prediction of the behavior of large superconducting coils in the radiation field of a future fusion reactor. The electrical and mechanical stability of such magnets is determined by the irradiation induced deterioration of the magnet components, i.e., (a) changes in critical current, field and temperature of the superconductor (NbTi, A-15 phases), (b) resistivity increase in the stabilizer (Cu, Al), and (c) changes in mechanical and dielectric properties of insulators and spacers. Recent low temperature simulation experiments (with fission neutrons and heavy ions) show that the superconductor will not be the critical component of a fusion magnet—at least as far as radiation damage is concerned. Much more severe is the loss of stability due to the resistivity increase of the stabilizing material. It seems, however, that the magnitude of this effect can be predicted rather reliably and therefore taken into account in the coil design. Almost no data exist about the low temperature behavior of insulator and spacer materials in a radiation field. Furthermore, very little is known about the nature of the radiation damage in non-metals, which makes extrapolations of the few existing data to other materials or to other doses highly speculative. Only future experiments can decide if the insulators will be the limiting component of a CTR magnet or not.

**5410** (CONF-750989—P2, pp II.422-II.435) **High-energy neutron irradiation of superconducting compounds.** Sweedler, A.R. (Brookhaven National Lab., Upton, NY); Snead, C.L.; Newkirk, L.; Valencia, F.; Parkin, D.M.; Geballe, T.H.; Schwall, R.H.; Matthias, B.T.; Corenswit, E. Mar 1976.

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The effect of high-energy neutron irradiation (E greater than 1 MeV) at ambient reactor temperatures on the superconducting properties of a variety of superconducting compounds is reported. The materials studied include the A-15 compounds $Nb_3Sn$, $Nb_3Al$, $Nb_3Ga$, $Nb_3Ge$ and $V_3Si$, the C-15 Laves phase $HfV_2$, the ternary molybdenum sulfide $Mo_3Pb$/sub 0.5/$S_4$ and the layered dichalcogenide $NbSe_2$. The superconducting transition temperature has been measured for all of the above materials for neutron fluences up to $5 \times 10^{19}$ n/cm$^2$. The critical current for multifilamentary $Nb_3Sn$ has also been determined for fields up to 16 T and fluences between $3 \times 10^{17}$ n/cm$^2$ and $1.1 \times 10^{19}$ n/cm$^2$.

**5411** (CONF-750989—P2, pp II.436-II.457) **Neutron irradiation effects on superconducting Nb—Ti alloys in the magnets for fusion reactors. Vol. II.** Okada, T. (Osaka Univ.); Tsubakihara, H.; Katoh, S.; Horiuchi, T.; Monjhu, Y.; Tsurutani, S. Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

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A study was made on the reactor irradiated single core copper-clad Nb-Ti wire, of which T/sub c/ and J/sub c/ were followed. A systematic preparation of the samples before irradiation involves (i) composition, (ii) degree of cold work, and (iii) aging time. Findings in the present study are that the neutron irradiation depressed J/sub c/ (at 5.0 T and 4.2°K) as much as 15 percent at certain condition and that T/sub c/ decreased by approximately 6 percent due to the same irradiation. The conditions that brought about these results are as follows: the sample: Nb-59.8 at percent Ti; cold work: 99.87 percent; heat treatment: $5 \times 10^3$ min at 380°C; irradiation: $1.3 \times 10^{18}$ n/cm$^2$ (E/sub n/ greater than or equal to 0.1 MeV). Specific feature of this sample is that $\alpha$-phase of Ti precipitates are dispersed in the $\beta$ = matrix. It is stressed that superconducting Nb-Ti wire with J/sub c/ enhanced by precipitates does not appear very resistant to neutron irradiation. Based on the results and taking irradiation effects on stabilizing normal conductor into consideration the over all effect to transport current density J/sub T/ is evaluated, which is presently believed to be one of the most convenient parameters for the evaluation of superconducting coil performance in the light of application to large-scale magnets. In connection with CTR technology normal/super ratio and the performance of the coil (J/sub T//sup M/) as a function of neutron fluence were determined.

**5412** (CONF-750989—P2, pp II.458-II.474) **Effect of stress-induced diffusion on void nucleation.** Wolfer, W.G.; Yoo, M.H. (Oak Ridge National Lab., TN). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

Interstitials and vacancies interact with voids through the image force as well as forces induced by the surface stress and gas pressure in the void. These forces cause a drift motion of the point defects to the void and thereby give rise to a bias. It is found that the bias of voids increases with decreasing void radius. Thus, it mainly influences the nucleation of voids rather than their growth. This bias of voids was incorporated into the nucleation theory developed by Katz, Wiedersich, and Russell, and studied the effect of surface energy, surface stress, temperature, dislocation bias, and gas pressure on the void nucleation. It is found that the critical void size is to a large extent determined by the condition that the interstitial bias of voids is equal to the bias of dislocations. Although the height of the activation barrier for nucleation depends on the bias factors also, it is affected more by surface energy, temperature, and above all, gas content. Since the bias of dislocations is largest when produced by small dislocation loops, it is concluded that void nucleation depends critically on the evolution of the dislocation structure. To obtain nucleation rates as observed experimentally one or preferably all of the following conditions must be met: A large dislocation bias, a reduction of the surface energy through contamination of the void surface, and a reduction of the void bias through impurity segregation.

**5413** (CONF-750989—P2, pp II.475-II.491) **Gas bubbles in stress and thermal gradients.** Hall, B.O.; Wiedersich, H. (Argonne National Lab., IL). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

Inert gases introduced into the first wall of a CTR by injection from the plasma and by (n,$\alpha$) reactions occurring in the wall tend to precipitate into bubbles. The forces on gas bubbles that arise from various sources of stress have been explored. The bubble is approximated by a center of dilatation in an elastically isotropic solid. The first-order size interactions of bubbles with elastic fields due to the presence of the surface, dislocations, other gas bubbles, and thermal gradients have been evaluated. The relative magnitudes of the resultant driving forces on the bubbles have been calculated, and their effect on bubble diffusion is discussed.

The region of validity of the center of dilatation approximation has been examined. The effects due to a finite bubble size are described.

**5414** (DP-MS—75-88) **Effect of hydrogen on the fracture toughness of 17-4 PH stainless steel.** Capeletti, T.L. (Du Pont de Nemours (E.I.) and Co., Aiken, S.C. (USA). Savannah River Lab.). 1976. Contract E(07-2)-1. 13p. (CONF-760819—12). Dep. NTIS $3.50.

From 2. international conference on the mechanical behavior of materials, Federation of Materials Societies; Boston, Massachusetts, United States of America (USA) (16 Aug 1976).

Fracture toughness (K/sub c/) of 17-4 PH stainless steel decreased significantly with increased hydrogen test pressure for a variety of heat treatment conditions: solution annealed, underaged, peak-aged, and overaged. Minimum toughness (13 MPa$\sqrt{m}$) was obtained with peak-aged samples tested in 69.5-MPa hydrogen; toughness was maximum (100 MPa$\sqrt{m}$) for samples tested in helium. Aging treatments increased the hardness from 28 R/sub c/ for solution-annealed material to 42 R/c/ for peak-aged material and correspondingly decreased the fracture toughness in high-pressure hydrogen (K/sub H/) from 31 to 13 MPa$\sqrt{m}$. However, increased hardness had no substantial effect on the K/sub c/ in helium. Fracture mechanism changed from predominantly ductile rupture in helium to cleavage in 69.5-MPa hydrogen, with mixed-mode fractures at lower hydrogen pressure (3.5-MPa). On the basis of these data, 17-4 PH stainless steel is not recommended for hydrogen service.

**5415** (HEDL-TC—68) **Working Group recommendations for metal swelling and creep equations for use in life.** Straalsund, J.L. (Hanford Engineering Development Lab., Richland, Wash. (USA)). Mar 1974. Contract E(45-1)-2170. 18p. Dep. NTIS $3.50.

Metal swelling and creep relations for 304 and 316 stainless steels are presented. Recommended equations are included for irradiation induced creep and thermal creep. (JRD)

**5416** (UCRL—52093) **Radiation damage at the Rotating Target Neutron Source (RTNS-I) facility at Lawrence Livermore Laboratory.** Logan, C.M.; Russell, E.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 9 Aug 1976. Contract W-7405-Eng-48. 71p. Dep. NTIS $4.50.

Some of the basic computational features of a computer program used for modeling radiation damage at LLL's Rotating Target Neutron Source (RTNS-I) are presented. Input items required are material cross-section and angular distribution data, such as used for LLL neutron transport calculations, along with one particular neutron spectrum of interest. The nuclear reactions considered are elastic, neutron-emitting, and charged-particle-emitting. Classical and relativistic mechanics are used as required to calculate the resulting primary-recoil energy spectra and damage energy spectra. Calculative results are presented for the RTNS-I neutron spectra on aluminum, titanium, vanadium, iron, nickel, copper, zirconium, niobium, molybdenum, silver, tin, tantalum, tungsten, gold, and lead. 63 figures.

**5417** (BNWL-tr—188) **Nickel—iron and nickel—silicon alloys which do not swell under fast-neutron irradiation.** Silvestre, G.; Silvent, A.; Regnard, C.; Sainfort, G. Translated from *J. Nucl. Mater.*; **57**: 125-135(1975). 30p. Dep. NTIS $4.00.

This research is concerned with the effect of fast-neutron irradiation on the swelling of nickel and nickel alloys. The materials studied were Ni—Fe (0 to 60 at. percent Fe) and Ni—Si (0 to 8 at. percent Si). The fluences were between $10^{20}$ and $4.3 \times 10^{22}$ n/cm$^2$. At low concentrations the added elements are in dissolved form and reduce swelling, silicon being very efficient. At higher concentrations, irradiation of Ni—Fe and Ni—Si alloys causes formation of plate-shaped precipitates of the $Ni_3X$ type, and these alloys do not swell. 18 figures.

**5418** **Structure of secondary-emission characteristics of single-crystal molybdenum.** Gomoyunova, M.V.; Zaslavskii, S.L.; Pronin, I.I. (A. F. Ioffe Physicotechnical Institute, Academy of Sciences of the USSR, Leningrad). *Sov. Phys. - Solid State (Engl. Transl.)*; **18**: No. 6, 796-798(May 1976).

The energy dependence of the structure of secondary emission from Mo was studied for primary electron energies in the range approximately-greater-than1 keV. The measurements were made by the retarding field method in a quasispherical capacitor with two grids.(AIP)

**5419** **Dose dependence of the photon emission from sputtered aluminum atoms during helium irradiation.** Braun, M.; Emmoth, B. (Research Institute for Physics, S-104 05, Stockholm, Sweden). *Appl. Phys. Lett.*; **29**: No. 9, 545-547(1 Nov 1976).

Polycrystalline aluminum samples are irradiated with 40-keV $He^+$. At moderate target temperatures (~0.3T/sub m/) a prominent and distinct enhancement of the light intensity from sputtered excited aluminum atoms is observed after implantation to a critical dose of $4 \times 10^{17}$ $He^+/cm^2$. It is shown that this effect is associated with a sudden increase in the erosion rate of Al and in the surface exfoliation due to radiation blistering. At higher target temperatures (~0.7T/sub m/) a less pronounced increase in the photon intensity and a different surface structure is observed. (AIP)

## CERAMICS, CERMETS, AND REFRACTORIES

*REFER ALSO TO CITATION(S) 5308*

### PREPARATION AND FABRICATION

*REFER ALSO TO CITATION(S) 4567, 5016, 5249*

**5420** (BM-RI—8053) **Electrolytic preparation of titanium and zirconium diborides from their oxides and mineral concentrates.** Gomes, J.M.; Uchida, K.; Wong, M.M. (Bureau of Mines, Washington, D.C. (USA)). 1975. 14p. Bureau of Mines, Washington, DC.

$TiB_2$, $ZrB_2$, and $HfB_2$ were electrodeposited from their respective oxides dissolved in borate-chloride-cryolite electrolytes. Titanium diboride was also electrodeposited from rutile ($TiO_2$) dissolved in a $Na_2B_4O_7$-$Na_2CO_3$-$Na_3AlF_6$-NaCl electrolyte at 1,050°C; 14 kWh were required to produce 1 lb of $TiB_2$. Major impurities in the $TiB_2$ produced in a 10-deposition cycle experiment, in weight-percent, were Al, 0.2; Cr, 0.3; Fe, 0.1; V, 0.3; C, 1.4; and O, 1.0. Zirconium diboride was electrodeposited from zircon ($ZrSiO_4$) dissolved in a $Na_2B_4O_7$-NaOH-$Na_3AlF_6$-NaCl-NaF electrolyte at 1,050°C. The $ZrB_2$ produced in a 10-deposition cycle experiment contained the following impurities in weight-percent: Fe, 0.1; Si, 0.5; C, 0.3; and O, 0.6. Energy required to produce 1 lb of $ZrB_2$ was 9.3 kWh.

**5421** (SAND—76-5318) **Electron microprobe studies of metal-ceramic braze joints.** Chambers, W.F.; Hlava, P.F. (Sandia Labs., Albuquerque, N.Mex. (USA)). 1976. Contract AT(29-1)-789. 5p. (CONF-760803—11). Dep. NTIS $3.50.

From 34. Electron Microscopy Society of America annual meeting; Miami Beach, Florida, United States of America (USA) (9 Aug 1976).

Methods of conducting stress analyses in metal-ceramic braze joints involving Kovar and alumina compositions are described. A schematic illustration of a braze configuration is included. The composition range for the glassy phase of the alumina system is tabulated. Through mixture theory, using measured and tabulated properties plus relative amounts of each phase, mechanical and physical properties of the metallized region of the alumina ceramic have been determined.

**5422** (EURFNR—1318) **Influence of deactivation processes on the sintering of $UO_2$ oxide fuel.** Pollanz, H.; Gutu, A. (Kernforschungszentrum Karlsruhe (Germany, F.R.). Inst. fuer Material- und Festkoerperforschung). Nov 1975. Translation of KFK—2226. 43p. Dep. NTIS $4.00.

Work performed under United States—Euratom Fast Reactor Exchange Program.

Methods were studied of sintering and final density control by deactivation processes using $UO_2$-oxide fuel. It was shown that sinterability decreases as a function of heating rate, the influence on final densities of sintered compacts being very small. Activated sintering by addition of ppM-amounts of water vapor to the sintering gas will influence pellet densities in a specific way. 6 tables, 16 figures.

### STRUCTURE AND PHASE STUDIES

*REFER ALSO TO CITATION(S) 5429*

**5423** **Color metallography of $U_3Si$.** Kimmel, G.; Nehama, E.; Tomer, A.; Bar-Or, A. (Nuclear Research Center, Beersheba, Israel). pp 37-43 of In Microstructural science. Vol. 4. Filer, E.W. (ed.). New York; Elsevier Publishing Co., Inc. (1976).

From 8. annual technical meeting of the International Metallographic Society; Bloomington, Minnesota, United States of America (USA) (1 Jul 1975).

See CONF-750774—.

Light metallography was found to be one of the main tools for observing the behavior of $U_3Si$ during its formation by the peritectoid reaction and also during plastic deformation. Uranium

silicon delta phase was obtained by chill casting, followed by a peritectoid reaction (deltizing) at 620, 720, 800 and 860°C. The microstructure of $U_3Si$ consists generally of transformation twins. The twin boundaries are mobile under stress. Light metallography of $U_3Si$ was used to investigate: (a) The distribution of additional phases in the $U_3Si$ matrix. (b) Existence or nonexistence of twins. A technique for etching $U_3Si$ at room temperature is presented. The result is selective coloring of crystallographic faces in various directions. This surface preparation enables to observe twins, grain distribution and oher phases in $U_3Si$. Typical structure of $U_3Si$ alloys after deltizing at different temperatures as well as after cold working are given in color. Previous methods are also reviewed.

## MECHANICAL PROPERTIES

*REFER ALSO TO CITATION(S) 4840, 4842, 5020, 5335*

**5424 Low temperature deformation of crystalline nonmetals.** Wolfson, R.G. (Dartmouth Coll., Hanover, NH). pp 333-392 of In Treatise on materials science and technology. VI. Arsenault, R.J. (ed.). New York; Academic Press, Inc. (1975).

Properties of those inorganic materials that can deform by crystallographic slip at room temperature are reviewed. Sections are included on semibrittle behavior, ionic crystals, covalent crystals, and suppression of brittle fracture. 272 references. (JRD)

**5425 Elastic constants of $V_2O_3$ in the temperature range 150—273degreeK.** Andrianov, G.O.; Drichko, I.L. (A. F. Ioffe Physicotechnical Institute, Academy of Sciences of the USSR, Leningrad). *Sov. Phys. - Solid State* (*Engl. Transl.*); **18**: No. 6, 803-804(May 1976).

Using measurements of the velocity of ultrasound, the temperature dependence of the elastic constants of $V_2O_3$ are studied. (AIP)

## PHYSICAL PROPERTIES

**5426** (CONF-750989—P4, pp IV.423-IV.447) **Tritium diffusion in ceramic CTR materials.** Fowler, J.D.; Chandra, D.; Causey, R.A.; Elleman, T.S.; Verghese, K. (North Carolina State Univ., Raleigh). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Gas release experiments have been used to measure diffusional release of recoil-injected tritons from the following materials: $Al_2O_3$ (single crystal, sintered and MgO-doped), BeO (single crystal and sintered), alpha-SiC (single crystal, hot pressed, and Al-doped), beta-SiC (single crystal), $Y_2O_3$, Yttralod, and SCB glass. Diffusion coefficients were obtained over five orders of magnitude at temperatures between 320°C and 1400°C. In most cases, fractional release curves are indicative of classical diffusion, and Arrhenius plots for a given material can be described by a constant activation energy. Characteristic activation energies varied from 30 to 70 kcal/mole. Isothermal diffusion coefficients increased by several orders of magnitude with the addition of small amounts of heterovalent impurities. Diffusion in the 0.1 weight percent MgO-doped alumina was five orders of magnitude larger than the single crystal alumina, and similar enhanced diffusion was observed for Al-doped SiC over undoped SiC.

**5427 Variation of emission properties with composition of ZrC + W alloys.** Komozynskii, P.A.; Ostrovskii, E.K.; Kalinina, N.G.; Neshpor, V.S.; Bednyak, L.G. (Khar'kov Aviation Institute; Institute of Applied Chemistry, Leningrad). *Sov. Phys. - Tech. Phys.* (*Engl. Transl.*); **21**: No. 3, 316-319(Mar 1976).

The thermonic-emission current density is studied as a function of the operating time of directly heated rod cathodes made of sintered ZrC-W alloys (20—98 wt. % W) and pure ZrC. The experiments are carried out at pressures below $2 \times 10^{-7}$ torr at T=2300°K. The emission current becomes stable after ~40 h of continuous cathode operation. With alloys containing 45—75% W at T=2300°K it is possible to obtain emission current densities at the level of 7.5—9 A/cm², while the emission current density for pure ZrC does not exceed 4 A/cm². In the operation of cathodes made from ZrC-W alloys, rings of nearly pure W (with Zr and C impurities) form on the cathode because of the evaporation of ZrC from the peripheral part of the cathode. The results found in measurements of the emission current density at the end of the tests (after 100 h of operation) are used to calculate the effective work function ($phi_{2300}$/sub degree/), which passes through a very shallow minimum (reaching 3.56 eV) in the ZrC-W system at a tungsten concentration of 35—85%. For cathodes containing less than 20% or more than 85% W, the value of $phi_{2300}$/sub degree/ is a strong function of the composition. It is suggested that cathodes made from alloys containing 20—85% W are cathodes of the film type (films of Zr and C adatoms on the surface of the tungsten ring); at other compositions these cathodes are patchy. (AIP)

**5428 Singularities of the Faraday effect on EuO films in megagauss fields.** Druzhinin, V.V.; Pavlovskii, A.I.; Samokhvalov, A.A.; Tatsenko, O.M. (Moscow Engineering Physics Institute). *JETP Lett. (USSR)* (*Engl. Transl.*); **23**: No. 5, 233-236(5 Mar 1976).

Measurements of the Faraday effect (FE) in pulsed magnetic fields on EuO films with oxygen vacancies has revealed two singularities: an abrupt increase of the FE in fields ~0.45 MOe, and an increase of the specific rotation to a value $3.7 \times 10^7$ deg/cm in fields ~ 0.8 MOe. The results are discussed. (AIP)

**5429 Phase transition in $V_2O_3$-$Ti_2O_3$ solid solutions.** Tallerchik, B.A.; Shustrov, B.A.; Novikov, V.N.; Gindin, E.I. *Sov. Phys. - Solid State* (*Engl. Transl.*); **18**: No. 6, 848-850(May 1976).

The $V_2O_3$-$Ti_2O_3$ solid solution is studied in the temperature range -180degreeC to +50degreeC. Among the properties examined are Mossbauer spectra, electric conductivity, thermoelectric power, and x-ray diffraction patterns. (AIP)

**5430 Optical properties of zirconium dioxide in the infrared region.** Aleksandrov, V.A.; Vasilev, A.B.; Kalgin, Y.A.; Kislovskii, L.D.; Tatarintsev, V.M. *Opt. Spectrosc.* (*USSR*) (*Engl. Transl.*); **40**: No. 6, 627-628(Jun 1976).

Infrared transmission spectra of $ZrO_2$ were studied experimentally. (AIP)

## CORROSION AND EROSION

*REFER ALSO TO CITATION(S) 4380*

**5431** (CONF-760503—13) **Compatibility of refractory materials with boiling sodium.** Meacham, S.A. (Westinghouse Electric Corp., Madison, Pa. (USA). Advanced Reactors Div.). 1976. Contract E(11-1)-2395. 11p. Dep. NTIS $3.50.

From International conference on liquified metal technology in energy production; Champion, Pennsylvania, United States of America (USA) (3 May 1976).

The program employed to determine the compatibility of commercially available refractories with boiling sodium is described. The effects of impurities contained within the refractory material, and their relations with the refractory's physical stability are discussed. Also, since consideration of refractories for use as an insulating material within Liquid Metal Fast Breeder Reactor Plants (LMFBR's) is currently under investigation; recommendations, based upon this program, are presented.

## RADIATION EFFECTS

*REFER ALSO TO CITATION(S) 4808, 4900, 4928, 5017, 5080, 5417*

**5432** (BNL—21531) **Studies on color-center formation in glass utilizing measurements made during 1 to 3 MeV electron irradiation.** Swyler, K.J.; Levy, P.W. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 9p. (CONF-760646—4). Dep. NTIS $3.50.

From Symposium on uranium plasmas; Princeton, New Jersey, United States of America (USA) (10 Jun 1976).

The coloring of NBS 710 glass has been studied using a new facility for making optical absorption measurements during and after electron irradiation. The induced absorption contains three Gaussian shaped bands. The color center growth curves contain two saturating exponential and one linear components. After irradiation the coloring decays and can be described by three decreasing exponentials. At room temperature both the coloring curve plateau and coloring rate increase with increasing dose rate. Coloring measurements made at a fixed dose rate but at increasing temperature indicate: (1) the coloring curve plateau decreases with increasing temperature and coloring has not been observed at 400°C; (2) the plateau is reached more rapidly as the temperature increases; (3) the decay occurring after irradiation cannot be described by Arrhenius kinetics. At each temperature the coloring can be explained by simple kinetics. The temperature dependence of the decay can be explained if it is assumed that the thermal untrapping is controlled by a distribution of activation energies.

**5433** (CONF-750989—P1, pp I.352-I.361) **Irradiation hardening and annealing in irons at a high neutron fluence.** Takeyama, T.; Takahashi, H.; Yokoya, N.; Kayano, H. (Tohoku Univ., Sendai). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The purpose of the present study is to obtain basic information for irradiation effect on two kinds of iron with different carbon content; specimen A (Fe-0.002 wt percent C), specimen B (Fe-0.012 wt percent C). The behavior of the lattice defects occurring due to neutron irradiation was investigated through electron microscopy and mechanical examination. After the irradiation, specimen A showed voids of about 500 A in size. The void density obtained through direct observation was about $1.0 \times 10^{14}/cm^2$. On the contrary, in specimen B the void was hard to observe. It was concluded that for the formation of voids by irradiation, specimens with less carbon atoms were desirable. The intriguing observation obtained through void formation showed that the yield stress of specimen A was higher than specimen B of high carbon content. The mechanism operating there may have much to do with the hardening which is caused by void formation.

**5434** (CONF-750989—P2, pp II.492-II.497) **Production of point defects in 14.8 MeV neutron-irradiated MgO.** Chen, Y. (Oak Ridge National Lab., TN); Abraham, M.M. Robinson, M.T.; Mitchell, J.B.; Van Konynenburg, R.A. Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

High-purity MgO crystals grown at ORNL have been irradiated in the LLL 14.8 MeV Rotating Target Neutron Source (RTNS) to doses varying from $1.8 \times 10^{15}$ to $5.7 \times 10^{17}$ n/cm². The optical absorption spectra of these crystals resembled those irradiated in fission reactors and exhibited bands principally at 4.95, 3.5, 2.2 and 1.3 eV. The band with the largest absorption coefficient, that at 4.95 eV, is due to anion vacancies. The bands at 3.5 and 1.3 eV, attended by zero-phonon lines at 3.430 and 1.187 eV respectively, have been attributed to different optical transitions of anion divacancies. Investigation results indicate that the net production rates of the point defects resulting from irradiations with 14.8 MeV neutrons are about twice those resulting from fission neutrons in the Oak Ridge Reactor (ORR). This ratio is in reasonable accord with theoretical estimates based on damage energy calculations.

**5435** (CONF-750989—P2, pp II.498-II.516) **Neutron irradiation damage in $Al_2O_3$ and $Y_2O_3$.** Clinard, F.W. Jr.; Bunch, J.M.; Ranken, W.A. (Los Alamos Scientific Lab., NM). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

Two ceramics under consideration for use in fusion reactors, $Al_2O_3$ and $Y_2O_3$, were irradiated in the EBR-II fission reactor at 650, 875, and 1025°K to fluences between 2 and $6 \times 10^{21}$ n/cm² (E greater than 0.1 MeV). Samples evaluated include sapphire, Lucalox, alumina, $Y_2O_3$, and $Y_2O_3$-10 percent $ZrO_2$ (Yttralox). All $Al_2O_3$ specimens swelled significantly (1 to 3 percent), with most of the growth observed in sapphire along the c-axis at the higher temperatures. $Al_2O_3$ samples irradiated at 875 and 1025°K contained a high density of small aligned "pores". Irradiated $Y_2O_3$-based ceramics exhibited dimensional stability and a defect content consisting primarily of unresolved damage and/or dislocation loops. The behavior of these ceramics under irradiation is discussed, and the relevance of fission neutron damage studies to fusion reactor applications is considered.

**5436** (CONF-750989—P2, pp II.517-II.530) **High energy proton simulation of 14-MeV neutron damage in $Al_2O_3$.** Muir, D.W.; Bunch, J.M. (Los Alamos Scientific Lab., NM). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

High-energy protons are a potentially useful tool for simulating the radiation damage produced by 14-MeV neutrons in CTR materials. Calculations and measurements of the relative damage effectiveness of these two types of radiation in single-crystal $Al_2O_3$ are described. The experiments make use of the prominent absorption band at 206 nm as an index to lattice damage, on the assumption that peak absorption is proportional to the concentration of lattice vacancies. The induced absorption is measured for incident proton energies ranging from 5 to 15 MeV and for 14-MeV neutrons. Recoil-energy spectra are calculated for elastic and inelastic scattering using published angular distributions. Recoil-energy spectra also are calculated for the secondary alpha particles and $^{12}C$ nuclei produced by (p, p'$\alpha$) reactions on $^{16}O$. The recoil spectra are converted to damage-energy spectra and then integrated to yield the damage-energy cross section at each proton energy and for 14 MeV neutrons. A comparison of the calculations with experimental results suggests that damage energy, at least at high energies, is a reasonable criterion for estimating this type of radiation damage.

**5437** (CONF-750989—P2, pp II.531-II.547) **Effects of ionizing radiation on electrical properties of refractory insulators.** van Lint, V.A.J. (Los Alamos Scientific Lab., NM); Bunch, J.M.; Flanagan, T.M. Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

The Los Alamos Reference Theta Pinch Reactor (RTPR) requires on the first wall an electrical insulator which will withstand transient high voltage at high temperature 10 s after severe neutron and ionizing irradiation. Few measurements of electrical parameters for heavily disordered refractory insulators have been reported; an estimate of whether breakdown strength or conductivity will be degraded by the irradiation is made. The approach treats separately short-term ionization effects (free and trapped electrons and holes) and long-term gross damage effects (transmutation products and various lattice defects). The following processes could produce unacceptable conduction across the first wall insulator: (a) delayed electronic conductivity 10 s after the prompt ionization by bremsstrahlung; (b) prompt electronic conductivity from delayed ionization; (c) electronic breakdown; (d) electronic or ionic conductivity due to thermal motion in the disordered material, possibly leading to thermal breakdown. Worst-case calculations based on lower limits to recombination coefficients limit process (a) to sigma much less than $5 \times 10^{-14}$ mho/cm. Data on ionization-induced conductivity in insulators predict for process (b) sigma much less than $10^{-9}$ mho/cm. Electronic breakdown generally occurs at fields well above the $10^5$ V/cm required for RTPR. Thermal breakdown is negligible due to the short voltage pulse. Ionic and electronic conduction must be studied theoretically and experimentally in the type of highly disordered materials that result from neutron irradiation of the first wall.

**5438** (SAND—76-5365) **Ionization-stimulated annealing effects on displacement damage in magnesium oxide.** Krefft, G.B. (Sandia Labs., Albuquerque, N.Mex. (USA)). 1976. Contract E(29-1)-789. 12p. (CONF-760921—3). Dep. NTIS $3.50.

From 23. National vacuum symposium; Chicago, Illinois, United States of America (USA) (21 Sep 1976).

The effects of ion bombardment into MgO were investigated by measuring resulting volume changes with a cantilever beam technique and by monitoring the F band absorption induced in the UV region of the spectrum. Single crystals of MgO were bombarded along (100) with 500 keV argon which resulted in an expansion of the implanted near-surface layer due to the ion-induced lattice damage. Under subsequent 100 keV proton irradiation, however, a large fraction of this expansion is relieved since the material compacts. This seems to indicate that defects with different charge states are produced in MgO by heavy ion bombardment and that electronic processes account for the volume changes observed during subsequent irradiation with the primarily ionizing radiation from the 100 keV $H^+$ implantation. Identical behavior was found earlier for the highly ionic $Al_2O_3$ while no such effect was observed in the predominantly covalent $SiO_2$. The present results thus corroborate the existence of defects with different charge states in ionic materials. This behavior of MgO and $Al_2O_3$ is of considerable interest since both materials are candidates for first-wall application in CTR environments.

## COMPOSITE MATERIALS

### PHYSICAL PROPERTIES

**5439** (CONF-750989—P4, pp IV.329-IV.360) **Experimental studies of tritium barrier concepts for fusion reactors.** Maroni, V.A.; Van Deventer, E.H.; Renner, T.A.; Pelto, R.H.; Wierdak, C.J. (Argonne National Lab., IL). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Ongoing experimental studies at ANL aimed at the development of methods to reduce tritium migration in fusion reactor systems currently include (1) work on the development of multilayered metal composites and impurity-coated refractory metals as barriers to tritium permeation in elevated temperature (greater than 300°C) structures and (2) investigations of the kinetics of tritium trapping reactions in inert gas purge streams under conditions that emulate fusion reactor environments. Significant results obtained thus far are (1) demonstration of greater than 50-fold reductions in the hydrogen permeability of stainless steel structures by using stainless steel-clad composites containing an intermediate layer of a selected copper alloy and (2) verification that surface-oxide coatings lead to greater than 100-fold reductions in the hydrogen permeability of vanadium, but that severe oxygen penetration and embrittlement of the vanadium occur at temperatures in the range from 300 to 800°C and under conditions of extremely low oxygen potential. Other considerations pertaining to the large-scale use of metal composites in fusion reactors are discussed, and progress in efforts to demonstrate the fabricability of metal composites is reviewed. Also presented are results of studies of the efficiencies of (1) CuO and $CuO—MnO_2$ beds in converting HT to HTO and (2) magnesium metal beds in converting HTO to HT.

**5440** (LA-UR—76-1861) **Magnetic field profiles of NbTi tapes.** Migliori, A.; Taylor, R.D.; Bartlett, R.D. (Los Alamos Scientific Lab., N.Mex. (USA)). 17 Aug 1976. Contract W-7405-eng-36. 4p. (CONF-760829—16). Dep. NTIS $3.50.

From Applied superconductivity conference; Stanford, California, United States of America (USA) (17 Aug 1976).

Magnetic field profile measurements were performed on stabilized NbTi tapes in zero applied field carrying large transport current densities. Field profile data were taken on large diameter superconducting sample loops at temperatures between 2°K and T/sub c/ (about 9.2°K) and several persistent currents up to I/sub c/(T), the maximum. The field profiles scaled with current, independent of temperature, at temperatures below 8.5°K and were well described by an elliptical shell approximation which left a current-free, field-free central region. Critical state models applied to this self-field situation proved inadequate. Complex profiles produced by trapped flux in the tape loop were described quantitatively by assuming concentric elliptical shells each with a different current density. The maximum current which could be persisted in the loop at each temperature was linear from 4 to 8.5 K. The effective resistance of the superconducting loop including its joint was less than $10^{-13}$ ohms.

### RADIATION EFFECTS

**5441** **Behaviour of carbon fibre composites under simulated space environment.** von Bassewitz, H. (Messerschmitt-Boelkow-Blohm G.m.b.H., Muenchen (F.R. Germany)). pp 525-537 of In Evaluation de l'action de l'environnement spatial sur les materiaux. Toulouse; Centre National d'Etudes Spatiales (Jun 1974).

From International conference on evaluation of space environment on materials; Toulouse, France (17 Jun 1974).

MBB is developing an ultra lightweight solar array for telecommunication spacecrafts in the power range of 5 to 10kW. The array structure consists of Carbon Fibre Reinforced Plastics, a material of which the behaviour under space conditions has been investigated in more detail. This compound material has been accepted by ESTEC for space application and will be used in the OTS solar array. CFRP samples have been exposed to different radiation modes (UV, electrons, protons) and subjected to thermal shocks to find out possible degradations of mechanical properties like stiffness and strength. Conditions of a 10 years lifetime in a synchronous orbit have been simulated where possible. The simulated space environment caused a property change in the range of 13% improvement down to 28% degradation. Where accelerated tests with higher radiation intensities (up to factor 10) have been applied, the measured degradation is looking more critical than it will be under orbit conditions.

## POLYMERS AND PLASTICS

### PREPARATION AND FABRICATION

**5442** (BDX—613-1298(Rev.)) **Feasibility study of production of 0.24 g/cm³-density polystyrene bead foam.** Palmer, R.W. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 22p. Dep. NTIS $3.50.

A development program at Bendix resulted in establishing the capability of molding uniform-density, high-strength polystyrene bead foam (PSBF). This work, directed specifically at nominal densities of 0.05 and 0.10 g/cm³, provided essential background for the current effort to determine the feasibility of expanding this capability to densities from 0.2 to 0.5 g/cm³. Activity was initiated in early FY 1974 at the request of Lawrence Livermore Laboratory to establish the feasibility of producing higher density PSBF. In the current phase of this project, the production of 0.24 g/cm³-density PSBF was investigated. It has been determined from this investigation that PSBF at 0.24 g/cm³ density can be produced with existing equipment. Material has been produced with density variations less than +-10 percent from nominal in sections as large as 42 inches (1.07 m) in diameter and 24 inches (0.6 m) high.

**5443** (Y/DL—521) **Production method for the vacuum impregnation of a large number of metallographic specimens.** Petretzky, P.B. (Oak Ridge Y-12 Plant, Tenn. (USA)). 1976. Contract W-7405-ENG-26. 9p. (CONF-760631—4). Dep. NTIS $3.50.

From 9. symposium on fusion technology; Garmisch-Partenkirchen, German, Federal Republic of (F.R. Germany) (14 Jun 1976).

A production method has been developed for the rapid vacuum impregnation of a large number of metallographic specimens. This impregnation method is accomplished by feeding epoxy to a number of specimens positioned on a rotary stage which is located in a vacuum chamber. The method is fast and simple, and can be utilized for impregnating various types of materials.

### MECHANICAL PROPERTIES

*REFER ALSO TO CITATION(S) 4493*

### PHYSICAL PROPERTIES

*REFER ALSO TO CITATION(S) 4491, 4520*

**5444** (BDX—613-1425(Rev.)) **Investigation of new engineering thermoplastics.** Walter, C.L. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 11p. Dep. NTIS $3.50.

Nine newly developed injection molding materials were characterized chemically and several of their physical properties were determined. These materials each have special characteristics which make them suitable for particular applications. Polyphenylene sulfide, methylpentene polymer, four proprietary thermoplastic polyester molding resins, plus both glass-filled polycarbonate and polyester injection moldable structural foam systems were evaluated.

**5445** (BNWL-B—430(Suppl.1)) **Polymeric media for tritium fixation. Supplement I.** Franz, J.A.; Burger, L.L. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). 15 Feb 1976. Contract E(45-1)-1830. 18p. Dep. NTIS $3.50.

Procedures for the fixation of tritium as TH or THO in two different polymeric media are described. The complete procedure for THO fixation in a polyureylene-polyurethane polumer, including polymer molding procedures and leach tests is presented. The catalytic tritiation of polystyrene under very mild conditions using a rhodium catalyst is also described. Thermal stabilities and cost estimates for the polymers examined under this program are discussed. Organic polymers were found to have attractive features for the fixation and storage of concentrated tritium wastes due to the convenience of fixation procedures and favorable properties of the resulting media.

**5446** (CONF-750989—P4, pp IV.176-IV.186) **Hydrogen isotope permeation in elastomeric materials.** Steinmeyer, R.H.; Braun, J.D. (Monsanto Research Corp., Miamisburg, OH). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The permeabilities of elastomeric and polymeric materials to hydrogen isotopes were measured at room temperature. The technique for measuring permeation rates is based on the following constant-volume method: a fixed pressure of gas is applied to one side of the specimen to be studied and the permeability constant is determined from the observed rate of pressure increase in an initially evacuated volume on the other side of the specimen. Permeability constants for hydrogen, deuterium, and tritium were measured for Mylar, Teflon, Kapton, Saran, Buna-N, and latex rubber. Results were compared with literature values for hydrogen and deuterium where available and showed excellent agreement.

**5447** (SAND—75-5458) **Technique for determining relaxation functions in linear viscoelastic materials.** Lindrose, A.M. (Sandia Labs., Albuquerque, N.Mex. (USA)). 1976. 5p. (CONF-760819—2). Dep. NTIS $3.50.

From 2. international conference on the mechanical behavior of materials, Federation of Materials Societies; Boston, Massachusetts, United States of America (USA) (16 Aug 1976).

An isotropic linear viscoelastic material undergoing a continuous uniaxial loading is described by Volterra integral equations of the first kind in which the kernels represent shear, bulk, and Young's moduli. This paper considers the determination of these moduli using stress and strain histories other than those of step response. A modified direct quadrature is used in the constitutive characterization of real materials. Experimental sinusoidal uniaxial stress data for low-density polyethylene show that, despite the nonlinearity of the material, the trend curves are biased in favor of the relaxation moduli of polyethylene at less than 1 percent strain. (DLC)

**5448** (UCRL—52044) **Properties of three Adiprene-based adhesives.** Hammon, H.G.; Hetherington, N. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 1 Apr 1976. Contract W-7405-Eng-48. 46p. Dep. NTIS $4.00.

Properties of Adiprene L-100, Adiprene L-315, and Adiprene LW-520 are reported. Information is included on cure rates, adhesive properties, tensile properties, shear rate temperature dependence, gas permeability, thermal expansion, transition temperature, density, chemical composition, and handling precautions. (JRD)

### RADIATION EFFECTS

*REFER ALSO TO CITATION(S) 5518*

**5449** **Thixotropic, radiation curable compositions.** Miller, L.S. (to Dow Chemical Co.). US Patent 3,963,798. 15 Jun 1976. Filed date 14 Jun 1974. 8p.

A reactive metal oxide or metal hydroxide, such as ZnO, MgO, HgO or $Ba(OH)_2$ and acrylic or methacrylic acid are added to a liquid, hydrophobic, essentially solvent-free coating vehicle capable of being cured by high-energy radiation. The resulting coating composition, as compared to the vehicle alone, can be cured with lower radiation doses, is less susceptible to oxygen inhibition of curing with ionizing radiation and exhibits a thixotropic viscosity which prevents excessive penetration of the coating into porous substrates and contributes non-drip, low-flow characteristics to the composition.

## OTHER MATERIALS

### STRUCTURE AND PHASE STUDIES

*REFER ALSO TO CITATION(S) 5324, 6112, 6113, 6115*

### PROPERTIES

*REFER ALSO TO CITATION(S) 5335, 5345, 5346, 5347, 5348, 5349, 5351, 5424, 5426, 5439, 6114*

**5450** (BNL—21688) **Effective crystal fields in the rare earth pnictides.** Herbst, J.F.; Bak, P.; Watson, R.E. (National Bureau of Standards, Washington, D.C. (USA); Brookhaven National Lab., Upton, N.Y. (USA)). Jul 1976. Contract E(30-1)-16. 6p. (CONF-760922—11). Dep. NTIS $3.50.

From International conference on magnetism; Amsterdam, Netherlands (6 Sep 1976).

Various contributions to the effective 4f electron crystal fields in the rare earth pnictides are estimated and compared. These include the direct interaction with the ligand electrostatic field and effects associated with the 5d band electrons.

**5451** (CONF-750989—P4, pp IV.83-IV.97) **$^3$He release characteristics of metal tritides and scandium—tritium solid solutions.** Perkins, W.G.; Kass, W.J.; Beavis, L.C. (Sandia Labs., Albuquerque, NM). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Tritides of such metals as Sc, Ti, and Er are useful materials for determining the effects of He accumulation in metallic solids, for example, CTR first wall materials. Such effects include lattice strain and gross deformation which are related to $^3$He retention and ultimate release. Long term gas release studies have indicated that, during the early life of a metal ditritide, a large fraction of the $^3$He is retained in the solid. At more advanced ages, the $^3$He release rate becomes comparable to the generation rate. Statistical analysis of the data indicates that the acceleration in $^3$He release rate depends on accumulated $^3$He concentration rather than strictly on age. $^3$He outgassing results are presented for thin films of $ScT_2$, $TiT_2$, and $ErT_2$, and the critical $^3$He concentrations are discussed in terms of a percolation model. Phase transformations which occur on tritide formation cast some doubt on the validity of extrapolating results obtained for metal tritides to predictions regarding the accumulation of helium in metals. Sc is unique among the early transition and rare-earth metals in that the metal exhibits a very high room temperature T solubility (T/Sc = 0.4) with no phase transformation. Indeed, even the lattice parameters of the hcp Sc lattice are only minimally changed by T solution. Single crystal ScT/sub 0.3/ samples in two crystallographic orientations were obtained. Using a very sensitive technique, $^3$He emission was measured from both these samples, as well as from fine-grained thin film Sc—T solid solution samples (ScT/sub 0.3-0.4/). The fine-grained film samples release $^3$He at 2-3 percent of the generation rate, while the emission rate from the single-crystal samples is approximately 0.05 percent of the generation rate, indicating a strong grain size effect.

**5452** (LBL—5129) **Structure and electrical properties of glass carbon.** Saxena, R.R. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). 19 Jun 1976. Contract W-7405-eng-48. 168p. Dep. NTIS $6.75.

Thesis.

Glassy carbon (GC) samples were heat treated at 1000 to 2800°C for different times to produce structural changes. Comparison of K-emission bands of graphite, diamond, and GC shows that GC may consist of both trigonally and tetrahedrally bonded C atoms, with the tetrahedral content decreasing with temperature. Single-crystal patterns are seen in transmission electron microscope studies. The interlayer spacing $d_{002}$ is reduced only to 3.40A° for GC heat treated at 2800°C for two hours (GC 2800-2). The crystallite size parameters L/sub c/, L/sub a/ (perpendicular and parallel to graphitic layers) grow only to 28 and 50A° respectively for GC 2800-2. Based upon the heat treatment variation of $d_{002}$, L/sub c/, and L/sub a/, three different temperature regions are found. The first region is over when dehydrogenation is completed. The second region is characterized by a constant $d_{002}$, and the increase in L/sub c/, L/sub a/ in this region may be due to stress relief. Kinetics in the third region give an activation energy of 200-225 (+-30) kcal/mole. The conductivity sigma and magnetoresistance DELTA rho/rho were studied. The temperature dependence of sigma is the sum of a temperature-independent contribution and a contribution due to the hopping conduction among localized states. For GC isochronally heat treated at HTT less than 2000°C, an anomalous contribution to sigma is found. The negative DELTA rho/rho increases with H and as T is reduced. An energy band model is proposed to explain the observed electrical properties, which consists of a pseudo-gap (with mobility shoulders) arising from localization of states due to disorder. (DLC)

**5453** (SAND—76-0359) **Electrical conductivity of memory-type $CdGeAs_2$ semiconducting glasses.** Johnson, R.T. Jr.; Quinn, R.K. (Sandia Labs., Albuquerque, N.Mex. (USA)). Aug 1976. Contract E(29-1)-789. 17p. Dep. NTIS $3.50.

Electrical conductivity changes associated with the thermally induced amorphous-to-crystalline transformation in $CdGeAs_2$ semiconducting glasses were examined. Results from these experiments, in conjunction with other materials considerations, suggest that the II-IV-V compound semiconducting glasses may be good memory-type materials in comparison to the chalcogenide glasses.

**5454** **Electron spin resonance of negative ions in liquid helium.** Zimmermann, P.H.; Reichert, J.F. (State Univ. of New York, Buffalo (USA). Dept. of Physics); Dahm, A.J. (Case Western Reserve Univ., Cleveland, Ohio (USA). Dept. of Physics). pp 244-247 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Electrons are injected into liquid helium, inside a sealed microwave cavity, by field emission from sharp metallic tips. The electrons move through a very small distance before they form a negative ion void. ESR signal intensities were studied as a function of microwave power and of tau/T, where tau is the transit time of an ion across the cavity and T is the transition time.

**5455** **Fine structure of the optical spectra of cubic crystals of Uranyl compounds.** Burkov, V.I.; Kizel, V.A.; Krasilov, Y.I. *Opt. Spectrosc. (USSR)* (*Engl. Transl.*); 40: No. 5, 469-472(May 1976).

It is shown that the splitting of the resonance transition in the low-temperature absorption and luminescence spectra of cubic crystals of uranyl compounds should be interpreted as Davydov splitting. (AIP)

**5456 Solubility of magnesium oxide in calcium oxide—calcium chloride mixtures.** Kucera, G.H.; Saboungi, M.L. (Argonne National Lab., IL.). *Metall. Trans., B;* **156**: No. 7B, 213-215(Jun 1976).

Measurements and theoretical calculations of the solubility product of magnesium oxide in calcium chloride-calcium oxide mixtures at 1133°K are reported. A filtration technique in an inert atmosphere was used to obtain samples for analysis by atomic absorption for magnesium content. At low concentrations of $O^{2-}$, the data are in consonance with the very low solubility product of $10^{-6.2}$ predicted by a simple thermodynamic cycle first proposed by Flood, Foerland and Grjotheim.

**5457** (SAND—76-6028) **Calcium chromate.** Mylius, F.; von Wrochem, J. Translated by B. Teague from *Wiss. Abh. Phys.-Tech. Reichsanst.;* 3: 459-477(Jul 1976). 32p. Dep. NTIS $4.00.

Properties of several forms of calcium chromate are reported. Descriptions are included on the monoclinic ($\alpha$) dihydrate $CaCrO_4 + 2H_2O$, the rhombic ($\beta$) dihydrate $CaCrO_4 + 2H_2O$, the monohydrate $CaCrO_4 + H_2O$, the hemihydrate $CaCrO_4 + 1/2\ H_2O$, and the anhydride $CaCrO_4$. (JRD)

## RADIATION EFFECTS

*REFER ALSO TO CITATION(S) 5410*

**5458 Resistance of organic and inorganic materials to high-energy radiation.** van de Voorde, M.; Lambert, K.P.; Schoenbacher, H. (European Organization for Nuclear Research, Geneva (Switzerland)). pp 505-514 of In Evaluation de l'action de l'environnement spatial sur les materiaux. Toulouse; Centre National d'Etudes Spatiales (Jun 1974).

From International conference on evaluation of space environment on materials; Toulouse, France (17 Jun 1974).

Requirements for a large variety of radiation resistant materials are made for the existing CERN high-energy installations, the 28GeV Proton Synchroton and the Intersecting Storage Rings, as well as for the Super Proton Synchrotron at present under construction which will accelerate protons up to 400GeV/c. Organic and inorganic materials used for magnets and cable insulations, for vacuum seals, supports, optical devices, etc., have been subjected to radiation damage tests. In order to make predictions and recommendations on the lifetime of such materials in a nuclear radiation field, accelerated tests have been carried out in various sources under combined environmental conditions mainly in nuclear reactors. The conclusive results of these tests are given and the validity of such simulating tests is discussed, based on the experience gained around the CERN accelerators now in operation for more than ten years.

**5459 Electronic and ionic charge carriers in irradiated single crystal and fused quartz.** Hughes, R.C. (Sandia Labs., Albuquerque, N.Mex. (USA)). *Radiat. Eff.;* **26**: No. 4, 225-235(Nov 1975).

The charge carrier transport properties of a wide variety of quartz single crystals and fused silica have been measured by creating electron-hole pairs in the bulk of the samples with high energy x rays. The very short x-ray pulses (3 nsec) allowed unprecedented time resolution, and in some cases separate measurements of carrier concentration, ($\alpha$) lifetime, (tau) and mobility, ($\mu$) as well as their product ($\alpha e \mu$tau). The $\alpha e \mu$tau product is sometimes called the radiation induced conductivity (RIC) and was found to vary over almost four orders of magnitude for different types of quartz. In addition, substantial long term conductivity was discovered in some kinds of single crystal quartz with the electric field parallel with the c-axis. It is concluded from the available evidence that the long lived carriers are alkali metal ions which can be drifted across the entire crystal. The possible origin of the ions is discussed as well as their role in the short term annealing of the radiation-induced frequency offsets noted in quartz oscillators.

**5460 Transient changes in quartz resonators following exposure to pulse ionization.** King, J.C.; Sander, H.H. (Sandia Labs., Albuquerque, N.Mex. (USA)). *Radiat. Eff.;* **26**: No. 4, 203-212(Nov 1975).

The transient effect of pulse ionization on the resonant frequency and Q of quartz resonators is reviewed. A number of different samples of both natural and synthetic quartz crystals have been used. Fifth-overtone 5,32, and 125 MHz thickness shear (AT-cut) crystal units were fabricated and studied using several different oscillator circuits, one of which was designed such that the resistance Rsub(s)($\alpha Q^{-1}$) of the crystal unit at series resonance as well as frequency could be measured after pulse exposure. With the exception of one purposely altered crystal, all the resonators exhibited a negative-transient frequency offset after irradiation which thereafter anneals as a function of tsup(-1/2) over nearly four decades of time. The pulse irradiation effect on $Q^{-1}$ is most striking at 5 MHz in natural quartz units, which suffer a thirty-fold increase in acoustic absorption after exposure to $10^4$ rad. The transient increase in the acoustic absorption in natural quartz anneals within 10 seconds to a value somewhat larger than the preir-radiation absorption. Theoretical models are described which account for these observations.

**5461 Effects of high-temperature electrolysis on the coloration characteristics and OH-absorption bands in alpha-quartz.** Krefft, G.B. (Sandia Labs., Albuquerque, N.Mex. (USA)). *Radiat. Eff.;* **26**: No. 4, 249-259(Nov 1975).

The effect of high-temperature electrolysis in vacuum on the formation of color centers and on the OH-spectrum in natural $\alpha$-quartz was investigated with numerous samples of different origin. The transformation of those OH-bands which are thermally unstable with respect to their spectral position into stable OH-bands at longer wavelength is strongly affected by electrolysis and seems to be related to the formation of color centers; it appears to take place at the leading edge of the color cloud. The OH-concentration in the crystal before electrolysis is directly proportional to the intensity of the coloration produced by electrolysis and is inversely propertional to the field induced propagation velocity of the color cloud as it moves from the anode to the cathode. The inverse proportionality of the absorption maxima of the C-band and 2.96- $\mu$m OH-band indicate a relationship which is interpreted as oxygen vacancy formation. Prolonged electrolysis in vacuum drastically reduced the integrated OH-spectrum and can virtually eliminate it. Since some of these OH-bands have been shown to be associated with interstitial monovalent impurities, the observed spectral changes give evidence that sweeping of $\alpha$-quartz along the optical axis is possible through vacuum electrolysis at elevated temperatures. The results are of particular interest with respect to the fabrication of quartz resonators since the Q and radiation sensitivity of quartz resonators are known to be strongly influenced by the presence of impurities.

**5462 Effects of $^{60}$Co $\gamma$-ray irradiation on the optical properties of natural and synthetic quartz from 85 to 300 K.** Mattern, P.L. (Sandia Labs., Livermore, Calif. (USA)); Lengweiler, K.; Levy, P.W. *Radiat. Eff.;* **26**: No. 4, 237-248(Nov 1975).

Optical absorption and luminescence measurements have been made between 85 and 300 K on natural and synthetic quartz during and after $^{60}$Co $\gamma$-ray irradiation. Absorption vs. dose curves can be resolved into the sum of a saturating exponential and linear component. At 85 K the slope of the linear component is small, while at 300 K the linear term dominates the growth curves. The coloring induced by irradiation at 85 K decreased in a complex manner during anneal at a linear rate to 300 K. During this annealing process multiple-peak thermoluminescent (TL) glow curves were observed and recorded. The TL emission spectra are described accurately by single Gaussian-shaped bands, whereas the $\gamma$-ray induced luminescence is comprised of several poorly resolved bands. All recorded TL glow curves are characterized by a set of four first order glow peaks between 150 and 220 K. The temperature dependence of radioluminescence intensity is described by a classical model in which a temperature-independent radiative transition competes with a thermally activated non-radiative process.

**5463 Stable [Li]$^0$ defects in MgO single crystals.** Abraham, M.M.; Chen, Y.; Boatner, L.A.; Reynolds, R.W. (Solid State Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830). *Phys. Rev. Lett.;* **37**: No. 13, 849-852(27 Sep 1976).

The [Li]$^0$ center has been formed in lithium-doped single crystals of MgO by high temperature quenching. In contrast to the [Li]$^0$ center formed by low-temperature $\gamma$ irradiation, the center formed by quenching is stable at room temperature. A heavy electron irradiation also produces stable [Li]$^0$ centers. Investigations using EPR and electron-nuclear double resonance techniques have established that, in all three cases, the [Li]$^0$ center has the same local configuration. The increased stability has enabled us to observe the motionally averaged [Li]$^0$ spectrum for the first time. Optical absorption data indicate that the center is associated with an absorption band at 1.83 eV. (AIP)

**5464 The ESR spectrum and structure of $BF^-_2$ .** Hudson, R.L.; Williams, F. (Department of Chemistry, University of Tennessee, Knoxville, Tennessee 37916). *J. Chem. Phys.;* **65**: No. 8, 3381-3382(15 Oct 1976).

The isotropic ESR spectrum of $BF^-_2$ in $\gamma$-irradiated solid solutions of 5 mole% $BF_3$ in tetramethylsilane (TMS) is reported. (AIP)

# CHEMISTRY

*REFER ALSO TO CITATION(S) 4368, 4369*

**5465** (COM—75-10943) **Catalog of NBS standard reference materials, 1975—76 edition. Special pub.** Seward, R.W. (National Bureau of Standards, Washington, D.C. (USA)). Jun 1975. 95p. (NBS-SP—260-1975-76). NTIS $4.75.

Library of Congress Catalog Card No. 75-1209. Paper copy also available from GPO as C13.10:260/1975-76 ed. Supersedes 1973 edition, COM—73-50570.

This Catalog lists and describes the Standard Reference Materials (SRM's), Research Materials (RM's), and General Materials (GM's) currently distributed by the National Bureau of Standards, as well as many of the materials currently in preparation. SRM's are used to calibrate measurement systems and to provide a central basis for uniformity and accuracy of measurement. The unit and quantity, the type, and the certified characterization are listed for each SRM, as well as directions for ordering. The RM's are not certified, but are issued to meet the needs of scientists engaged in materials research. RM's are issued with a 'Report of Investigation', the sole authority of which is the author of the report. The GM's are standardized by some agency other than NBS. NBS acts only as a distribution point and does not participate in the standardization of these materials. Announcements of new and renewal SRM's, RM's and GM's are made in the semiannual supplements of this Catalog, SRM Price List, and in scientific and trade journals. (GRA)

## ANALYTICAL AND SEPARATIONS CHEMISTRY

*REFER ALSO TO CITATION(S) 4408, 4824*

**5466** (HASL—300(Suppl.3)) **HASL procedures manual.** Harley, J.H. (ed.). (Energy Research and Development Administration, New York (USA). Health and Safety Lab.). Aug 1975. 67p. Dep. NTIS $4.50.

Changes and additions for the HASL Procedures Manual, HASL-300, are given. (LK)

**5467** (HASL—300(Suppl.4)) **HASL procedures manual.** Harley, J.H. (ed.). (Energy Research and Development Administration, New York (USA). Health and Safety Lab.). Aug 1976. 139p. Dep. NTIS $6.00.

The following sections are contained in the manual: general; sampling; field measurements; radiochemical and radiometric analysis; chemical procedures; data; and specifications. (LK)

### ACTIVATION AND NUCLEAR REACTION PROCEDURES

*REFER ALSO TO CITATION(S) 4445*

**5468** (CONF-750989—P4, pp IV.158-IV.175) **Techniques for studying hydrogen and helium isotopes in materials: ion backscattering and nuclear microanalysis.** Langley, R.A. (Sandia Labs., Albuquerque, NM). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The techniques of ion backscattering and nuclear microanalysis as tools for studying hydrogen and helium isotopes in solid materials are discussed and compared. The advantages, disadvantages and limitations of each of these techniques are explored. Experimental results obtained using the two techniques are analyzed to obtain information on concentration-versus-depth profiles for these light atoms in heavy atom substrates.

**5469** (CONF-750989—P4, pp IV.187-IV.202) **Depth profiling of tritium by neutron time-of-flight.** Davis, J.C.; Anderson, J.D.; Lefevre, H.W. (Univ. of Oregon, Eugene). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

A method to measure the depth profile of tritium implanted or absorbed in materials was developed. The sample to be analyzed is bombarded with a pulsed proton beam and the energy of neutrons produced by the T(p,n) reaction is measured by the time-of-flight technique. From the neutron energy the depth in the target of the T atoms may be inferred. A sensitivity of 0.1 at. percent T or greater is possible. The technique is non-destructive and may be used with thick or radioactive host materials. Samples up to 20 $\mu$m in thickness may be profiled with resolution limited by straggling of the proton beam for depths greater than 1 $\mu$m. Deuterium depth profiling has been demonstrated using the D(d,n) reaction. The technique has been used to observe the behavior of an implantation spike of T produced by a 400 keV $T^+$ beam stopping at a depth of 3 $\mu$m in 11 $\mu$m thick layers of Ti and TiH. The presence of H in the Ti lattice is observed to inhibit the diffusion of T through the lattice. Effects of the total hydrogen concentration (H + T) being forced above stochiometry at the implantation site are suggested by the shapes of the implantation spikes.

**5470** (USGS-OFR—75-436, pp 79-81) **Determinations of uranium and thorium in rocks and soils by the delayed neutron technique.** Millard, H.T. Jr. 1975.

In Geochemical survey of the western coal regions. Second annual progress report, July 1975.

The basis for the analytical technique of neutron activation-delayed neutron counting is the emission of "delayed" neutrons by the fission daughters of uranium and thorium. These neutrons can be detected and counted with good discrimination and efficiency and thus the technique is both specific and sensitive. It allows the rapid, precise, and nondestructive determination of uranium to about 0.1 ppM and thorium to about 1 ppM in 10-gram samples of rocks and soils. Lower detection limits for uranium can be realized by recycling the same sample several times and thus improving the counting statistics. A summary of the procedure is presented.

### CHEMICAL PROCEDURES

**5471** (ARH-ST—108) **Determination of hydroxide in the presence of aluminate using a modified potentiometric titration.** Hanson, T.J. (Atlantic Richfield Hanford Co., Richland, Wash. (USA)). Nov 1975. Contract E(45-1)-2130. 25p. Dep. NTIS $3.25.

A procedure for the determination of hydroxide concentration in the presence of aluminate and other interfering ions was developed using the method of standard additions (or more specifically in this case, standard subtractions). The procedure called for titration with a strong acid which was added in equal increments at regular time intervals. The potential was recorded after each addition of acid. The data was plotted on Gran's Plot Paper, which is based on work done originally by Gran, or it was entered into a computer to determine the equivalence volume of the titrant. When used on many different samples in different matrices, the method gave results that were approximately 100 +- 1 percent of the calculated value. This was shown to be true even in systems containing aluminate [$Al(OH)_4^-$], phosphate ($PO_4^{3-}$), sulfate ($SO_4^{2-}$), nitrate ($NO_3^-$), nitrite ($NO_2^-$), carbonate ($CO_3^{2-}$), and other ions. The effect of these ions was shown to be negligible if the initial $OH^-$ concentration was at least $10^{-3}$ M and barium chloride ($BaCl_2$) was added to complex the $PO_4^{3-}$ and $CO_3^{2-}$ ions. These ions were checked at levels of up to 3 M for $Al(OH)_4^-$ and $NO_3^-$, 2 M for $NO_2^-$, and 1 M for $SO_4^{2-}$, $PO_4^{3-}$, and $CO_3^{2-}$. The method is applicable to radioactive as well as nonradioactive samples and any heat involved with a radioactive sample is insufficient to cause an error in the determination. On the basis of the work performed it was shown that the method was general enough to be run on a routine basis.

**5472** (MLM—2322) **Determination of chlorate in potassium perchlorate pyrotechnic material by specific ion electrode.** Yates, W.G. (Mound Lab., Miamisburg, Ohio (USA)). 31 Aug 1976. Contract E-33-1-GEN-53. 12p. Dep. NTIS $3.50.

A method for the determination of chlorate ion in potassium perchlorate was developed. The analytical method utilized a reduction of the chlorate ion to the chloride ion with ferrous ammonium sulfate. The chloride ions produced by this reduction step were then determined with a specific ion electrode technique. The amount of chlorate ion was determined by calculating how much chlorate ion was represented by the analyzed chloride ion making an appropriate adjustment for the amount of free chloride ion found in the potassium perchlorate and deionized water.

**5473** (NBL—281) **Chemical analysis of high temperature gas-cooled reactor fuel material.** Hedrick, C.E. (Energy Research and Development Administration, New Brunswick, N.J. (USA). New Brunswick Lab.). Aug 1976. 15p. Dep. NTIS $3.50.

High temperature gas-cooled reactor fuel material is inert and difficult to analyze chemically. In this report, four methods are reviewed for the analysis of this material, including two salt fusion methods, a chlorination method and a high precision grind-burn-leach method. In the grind-burn-leach method HTGR fuel samples are ground under an inert liquid. The inert liquid is subsequently separated by filtration and the ground sample is ignited to convert

all of the uranium and thorium to oxide. The ignited samples are then leached. The leach solutions and the leach residues are analyzed separately. Using this method, ten synthetic HTGR fuel standards were analyzed with a recovery of 99.97 +- 0.10 percent (RSD). In addition, ten HTGR fuel microsphere samples were analyzed with a precision of 0.18 percent (RSD). Although the chlorination method is found to be less time consuming than the grind-burn-leach or fusion methods, the grind-burn-leach method was found to offer an advantage in accuracy and precision over the other types of methods.

**5474** (UCRL—52045) **Total organic carbon analyzer: functional description.** Crawford, R.W.; Rigdon, L.P. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 1 Apr 1976. Contract W-7405-ENG-48. 25p. Dep. NTIS $3.50.

This document is the specification for computer automating a Beckman Model 915 total organic carbon analyzer. It describes the projected software and hardware needed to do the job. Operator inputs and interaction during the run are described. Computer output during and at the end of the run are described and illustrated. The computer calculates concentrations, monitors quality control, and prepares reports.

## RADIOMETRIC AND RADIOCHEMICAL PROCEDURES

*REFER ALSO TO CITATION(S) 4567, 5609, 5734*

**5475** (KY—672) **Analysis of $^{99}$Tc in metal by bremsstrahlung.** Williams, J.C.; Karr, P.S.; Beverly, C.R. (Paducah Gaseous Diffusion Plant, Ky. (USA)). 1 Sep 1976. Contract W-7405-eng-26. 14p. Dep. NTIS $4.50.

A large volume of radioactively contaminated nickel is being generated from scrap as a result of the Cascade Improvement and Uprating programs of the ERDA gaseous diffusion plants. With appropriate conditions, melting of the scrap reduces the contaminating radioactive isotopes of uranium, $^{237}$Np and $^{239}$Pu below 3 ppM, 1 x $10^{-8}$ ppM and 1 x $10^{-8}$ ppM, respectively. The fission product nuclide, $^{99}$Tc, is not removed in the melting process. It has been shown that bremsstrahlung produced from beta emissions is a reliable measure of the concentration of $^{99}$Tc. The lower limit of detection is estimated to be 100 ppb +- 50 ppb with a Ge(Li) detector. A count time of five minutes is sufficient to determine a concentration of 5 ppM +- 1 ppM. It has also been shown that $^{235}$U and $^{237}$Np can be determined to be less than 3.5 ppM and 1 x $10^{-3}$, respectively by gamma spectroscopy techniques in samples containing traces of $^{99}$Tc.

**5476** (MLM—2312) **Gamma-ray isotopic ratio measurements for the plutonium inventory verification program.** Lemming, J.F.; Haas, F.X.; Jarvis, J.Y. (Mound Lab., Miamisburg, Ohio (USA)). 25 Aug 1976. Contract E-33-1-GEN-53. 13p. Dep. NTIS $3.50.

The Plutonium Inventory Verification Program at Mound Laboratory provides a nondestructive means of assaying bulk plutonium-bearing material. The assay is performed by combining the calorimetrically determined heat output of the sample and the relative abundances of the heat-producing isotopes. This report describes the method used for the nondestructive determination of plutonium-238, -240, -241 and americium-241 relative to plutonium-239 using gamma-ray spectroscopy for 93 percent plutonium-239 material. Comparison of chemical data on aliquots of samples to the nondestructive data shows accuracies of +-7 percent for $^{238}$Pu/$^{239}$Pu, +-15 percent for $^{240}$Pu/$^{239}$Pu, +- 3 percent for $^{241}$Pu/$^{239}$Pu, and +-7 percent for $^{241}$Am/$^{239}$Pu.

## SPECTRAL PROCEDURES

*REFER ALSO TO CITATION(S) 5499*

**5477** (IS—3830) **Bibliography of mass spectroscopy literature for 1973 compiled by a computer method. Bibliography and author index.** Capellen, J.; Svec, H.J.; Sage, C.R.; Sun, R. (comps.). (Ames Lab., Iowa (USA)). Jun 1976. Contract W-7405-eng-82. 832p. Dep. NTIS $21.25.

This report covers the year 1973, and lists approximately 8,000 articles of interest to mass spectroscopists. This report consists of three sections, a Bibliography section, an Author Index section and a Key Word Out of Context Index (KWOC Index) section. The Bibliography section lists the authors, the title and the publication data for each article. The Author Index lists the authors' names and the reference numbers of their articles. The KWOC Index lists the key words, the reference numbers of the articles in which the key word appears and the first 100 characters of the title.

**5478** **Determination of stable sulfur isotope ratios in the environment.** Holt, B.D. (Argonne National Lab., Ill. (USA)). *Prog. Nucl. Energy, Ser. 9;* **12**: No. 1, 11-26(Mar 1975).

Modern applications of stable sulfur isotope measurements to environmental studies are cited, and analytical methods that have been developed by various researchers to yield the desired isotopic data are presented. Examples are given of sulfur isotope ratio measurements made in investigations of chemical and physical processes occurring in the atmosphere, in oceans, lakes, streams and groundwater; in mineral and petroleum formations; and in laboratory experiments that simulate natural processes. Sampling procedures are reviewed for the atmosphere, waters and minerals. A variety of tested analytical procedures are given in practical detail for the conversion of natural samples (atmosphere, water, minerals, etc.) to $SO_2$ or $SF_6$, suitable for mass spectrometric analysis. A procedure generally followed in the mass spectrometric measurement of the stable sulfur isotope ratios is also given, and a convenient gas inlet system to the mass spectrometer is shown.

## SEPARATION PROCEDURES

*REFER ALSO TO CITATION(S) 4550, 4552, 4553, 4554, 4555, 4571, 4595, 4603*

**5479** **Process for removing nitrogen oxides from gas.** Senjo, T.; Kobayashi, M. (to Fuji Kasui Engineering Co., Ltd.). US Patent 3,957,949. 18 May 1976. Priority date 10 Apr 1973, Japan. 8p.

A process for efficiently removing nitrogen oxides with a very high rate from waste gas is provided wherein nitrogen monoxide contained in the gas is oxidized by chlorine dioxide or ozone, and then the oxidized gas is brought into contact with sodium chlorite in water solution in an absorption column.

**5480** **Solvent extraction of uranium for dilute solutions using a gas-bubble mixed extraction column.** Andreine, R.J. (International Nickel, Inc., Sterling Forest, NY); Lower, G.W.; DeMull, T.J. Jr. *Metall. Trans., B;* **156**: No. 7B, 253-258(Jun 1976).

A modified solvent extraction process for recovering uranium from very dilute solutions, such as mine waters or copper dump liquors, has been developed and tested on a laboratory scale. The system utilizes a column in which the aqueous feed flows downward through a liquid organic extractant. A countercurrent flow of gas is used to achieve mixing and enhance mass transfer. Acid sulfate solutions at pH 1.5 containing either 0.010 or 0.015 g/l $U_3O_8$ comprised the feed. The extractant used was Alamine 336 dissolved in fuel oil. Critical parameters of the system, such as length to diameter ratio of the organic phase, volume ratio of aqueous to organic in the column, and flow rates of aqueous feed and gas are examined.

**5481** **Process of desulfurizing hot gases.** Bratzler, K.; Doerges, A.; Kempf, G.; Rudolph, P.; Schlauer, J. (to Metallgesellschaft Aktiengesellschaft). US Patent 3,963,825. 15 Jun 1976. Priority date 4 Jun 1971, German, Federal Republic of (F.R. Germany). 10p.

Gases produced by reacting fuels with oxygen-containing gases and water vapor under pressure are desulfurized by scrubbing with a concentrated solution of one or more alkali salts of weak inorganic acids at a temperature near the atmospheric-pressure boiling point of the solution in a column while maintaining an exchange ratio of from 0.2 to 2.0 cubic meters of the concentrated solution per standard cubic meter hydrogen sulfide in the gas to be purified.

**5482** **Selective removal of sulfur compounds from acid gas mixtures containing significant quantities of carbonyl sulfide.** Sykes, J.A. Jr. (to Shell Oil Co.). US Patent 3,965,244. 22 Jun 1976. Filed date 27 Nov 1974. 12p.

Acidic gases containing $H_2S$, $CO_2$ and substantial concentrations of COS are reduced in sulfur content by contacting said gases in a first stage at elevated temperatures with an aqueous polyalkanolamine solution containing at least 20 percent by weight of a tetramethylene sulfone. A substantial portion of the COS present is hydrolyzed to $H_2S$ and $CO_2$, after which the hydrolyzed acid gases consisting substantially of $H_2S$ and $CO_2$ are contacted in a second stage with an alkanolamine absorbent for $H_2S$ under conditions where $H_2S$ is selectively removed to low levels.

**5483** **Process for recovering tungsten from alkaline leaching solution of tungsten ores.** Onozaki, S.; Nemoto, S.; Hazeyama, T. (to Nittetsu Mining Co., Ltd.). US Patent 3,969,484. 13 Jul 1976. Priority date 22 Mar 1974, Japan. 6p.

This invention relates to a process for recovering tungsten from an alkaline leaching solution of tungsten ores. This invention comprises adjusting the pH of an alkaline leaching solution which is obtained by lixiviating ore containing tungsten with an alkaline solution to 7—8 with acid to oxidize molybdic acid ions in the solution, adding a sulfide donor, then precipitating molybdenum sulfide compounds by adjusting the pH value of the solution to 2—3. Tungstic acid ions are recovered as calcium tungstate by the

addition of a calcium ion donor after the molybdenum sulfide compounds are separated.

**5484 Process for separation of tungsten and molybdenum by extraction.** Zelikman, A.N.; Voldman, G.M.; Rumyantsev, V.K.; Ziberov, G.N.; Kagermanian, V.S. US Patent 3,969,478. 13 Jul 1976. Filed date 30 Jan 1975. 8p.

A process for the separation of tungsten and molybdenum by extraction involves the addition of HCl or $HNO_3$ to an aqueous solution containing tungsten and molybdenum to obtain a pH from 0.5 to 4.3, and introduction of a stabilizer comprising water-soluble phosphorus salts and a complexing agent, hydrogen peroxide, in an amount from 1.5 to 2 mole per l g-atom of the total content of tungsten and molybdenum. Then molybdenum is selectively extracted from the resulting aqueous solution with tri-n-butylphosphate with equal volumetric proportioning of the aqueous and organic solutions. Re-extraction of molybdenum and partially tungsten is carried out from the organic extracting agent with an alkali or soda solution. The process makes possible the preparation of tungsten solution containing no more than 0.001 g/l of molybdenum, and an increase in the degree of extraction of tungsten and molybdenum.

## INORGANIC AND PHYSICAL CHEMISTRY

**5485** (RFP-Trans—196) **Kinetics of synthesis of calcium cyanamide from calcium oxide, carbon monoxide, and ammonia.** Pimenova, A.A.; Sangov, S.A.; Leykin, Z.M. Translated from *Tr. Tashk. Politekh. Inst.;* **107**: 49-50(1973). 1p. Dep. NTIS $3.50.

The $NH_3$ concentration in the gaseous mixture affects the $N_2$ accumulation in the product more severely than the CO concentration. Above 16 percent $NH_3$ and 20 percent CO, the reaction rate does not depend on gas composition and the reaction order is zero. Below these values, the reaction is first order for CO and second order for $NH_3$. (DLC)

### CHEMICAL AND PHYSICOCHEMICAL PROPERTIES

*REFER ALSO TO CITATION(S) 4614, 4615, 4730, 4731, 5420, 5691*

**5486** (BNWL-tr—183) **New family of isotonic mineral clathrates of gas and liquid hydrates. Interpretation of results.** Cros, C.; Pouchard, M.; Hagenumller, P. Translated from *J. Solid State Chem.;* 2: 570-581(1970). 24p. Dep. NTIS $3.50.

The thermal degradation of the alkali metal silicides and germanides of formula MeSi and MeGe (Me = Na, K, Rb, Cs) leads to intermediate phases having the clathrate structure of the gas and liquid hydrates. The alkali metal atoms occupy holes in a distorted silicon or germanium lattice; a radius intermediate between the ionic and metallic radii accounts for the experimental results involving a certain localization of the peripheral electron. This conclusion is confirmed by the magnetic and electric properties.

**5487** (ORNL-tr—4195) **Determination of absolute rate constants for the attachment of thermal electrons by $CCl_4$, $SF_6$, $C_4F_8$, $C_7F_{14}$, $N_3F_4$, and $NF_3$.** Mothes, G.; Schindler, R.N. Translated by R.G. Mansfield from *Ber. Bunsenges. Phys. Chem.;* 75: No. 9, 938-945(1971). 18p. Dep. NTIS $3.50.

The following absolute rate constants k[$cm^3$ . $molecule^{-1}$ . $s^{-1}$] for the attachment of thermal electrons in the gas phase have been determined by electron cyclotron resonance: k/sub $CCl_4$/ = 4.1 x $10^{-7}$, k/sub $SF_6$/ = 2.6 x $10^{-7}$, k/sub $C_4F_8$/ = 1.1 x $10^{-7}$, k/sub $C_7F_{14}$/ = 5.2 x $10^{-8}$, k/sub $N_3F_4$/ = 3.8 x $10^{-9}$, and k/sub $NF_3$/ = 2.4 x $10^{-11}$. Results are compared with values obtained by use of other methods. From the measured cross sections for the attachment process in $SF_6$ and $C_4F_8$ electron affinities of 1.3 eV and 0.61 eV respectively are calculated.

**5488** (RFP-Trans—197) **Thermal dissociation of lithium peroxide and its reaction with carbon dioxide.** Popova, T.I.; Pavlyuchenko, M.M. 1973. Translation of pp 85-86 from Tezisy Dokladov na Vsesoyuznom Soveshchanii po Khimii Neorganicheskikh Perekisnykh Soedinenii, Riga, 1973. 2p. Dep. NTIS $3.50.

Decomposition of $Li_2O_2$ in vacuum occurs at constant rate at 270 to 300°C and increases at 300—320°C. Activation energy is 55.8 kcal/mole. The rate-determining step is the escape of oxygen: $(O—O)^{2-}$ yields $O^{2-}$ + O. $Li_2O_2$ reacts completely with $CO_2$ at 270 to 300°C to form the carbonate; at 200 to 250°C $Li_2C_2O_6$ is also formed. $Li_2O_2$—$MeSO_4$ systems are decomposed at 240—250°C. (DLC)

**5489 Function of sulfur dioxide in the kinetic mechanism of oxidation of carbon.** Yang, R.T.; Steinberg, M. (Brookhaven National Lab., Upton, N.Y. (USA)). *Carbon;* 13: No. 5, 411-416(1975).

Retardation of the gasification reaction of carbon with oxygen by $SO_2$ was observed. Rates of oxidation were determined by thermal gravimetric analysis (TGA) of a nuclear graphite in the temperature range of 550 to 700°C, and of a coconut charcoal in the temperature range of 400 to 505°C. The oxidant gases were dry air containing 0 to 6% $SO_2$. Reduction of the rate by $SO_2$ varied with burn-off. Differential thermal analysis (DTA) was also applied to detect the retardation effect of $SO_2$. The technique of infrared internal reflection spectroscopy (IRS) was used to examine the surface species of reacted charcoal samples. Absorption bands were assigned to surface carbonyls, lactones, and a chemisorbed $SO_2$ in the form of sulfate. Retardation of the oxidation reaction was attributed to chemisorption of $SO_2$.

**5490 Tetracobalt decacarbonyl disulfide, $S_2Co_4(CO)_{10}$.** Wei, C.H.; Dahl, L.F. (Oak Ridge National Lab., TN). *Cryst. Struct. Commun.;* 4: 583-589(1975).

Results of an x-ray study of tetracobalt decacarbonyl disulfide are presented in tabular form. The study has established a dimeric model of $[SCo_2(CO)_5]_2$ with approximately D/sub 2h/ symmetry. (BLM)

**5491** (RFP-Trans—203) **Reaction of calcium hydroxide with carbon dioxide.** Dorst, F.W. Translated from *Prax. Naturwiss., Teil 3;* 24: No. 5, 126(1975). 2p. Dep. NTIS $3.50.

Details for carrying out an experiment on the reaction of calcium hydroxide with carbon dioxide are given. The addition of water is necessary for a reaction between dry calcium hydroxide and carbon dioxide. (LK)

**5492 Standard enthalpy of solution and formation of cesium chromate. Derived thermodynamic properties of the aqueous chromate, bichromate, and dichromate ions, alkali metal and alkaline earth chromates, and lead chromate.** O'Hare, P.A.G.; Boerio, J. (Argonne National Lab., Ill. (USA)). *J. Chem. Thermodyn.;* 7: No. 12, 1195-1204(Dec 1975).

From IAEA symposium on thermodynamics of nuclear materials; Vienna, Austria (Oct 1974).

Presented at symposium in part only.

Calorimetric measurements of the enthalpy of solution of cesium chromate gave $\Delta H$/sub soln/ = (7622 +- 24) cal/sub th/$mol^{-1}$ for a dilution of $Cs_2CrO_4.21128H_2O$. This result along with the enthalpy of dilution gave the standard enthalpy of solution, $\Delta H$/sub soln//sup o/ (7512 +- 31) cal/sub th/$mol^{-1}$, whence the standard enthalpy of formation, $\Delta H$/sub f//sup o/($Cs_2CrO_4$, c, 298.15 K), was calculated to be -(341.78 +- 0.46) kcal/sub th/$mol^{-1}$. Recomputed thermodynamic data for the formation of the other alkali metal chromates have been tabulated. From their solubilities and enthalpies of solution, the standard entropies, $S^o$(298K), of $BaCrO_4$ and $PbCrO_4$ were estimated to be (38.9 +- 0.9) and (43.7 +- 1.2) cal/sub th/ $K^{-1}mol^{-1}$, respectively. There is evidence that $\Delta H$/sub f//sup o/($SrCrO_4$, c, 298.15 K) may be in error. Thermochemical, solubility, and equilibrium data, have been combined to update the thermodynamic properties of the aqueous chromate ($CrO_4^{2-}$), bichromate ($HCrO_4^-$), and dichromate ($Cr_2O_7^{2-}$) ions. The new values at 298.15 K are tabulated.

**5493 Moessbauer spectroscopic study of some ferric polyaminocarboxylates.** Stein, G.E.; Marinsky, J.A. (State Univ. of New York, Buffalo). *J. Inorg. Nucl. Chem.;* 37: No. 12, 2421-2428(Dec 1975).

Ferric salts of EDTA, HEDTA, CDTA and NTA were examined using nuclear $\gamma$-ray resonance spectroscopy to determine the relative amounts of monomeric and dimeric anion present in the solid, solution, polyelectrolyte and ion exchanger phases as a function of the pH of the equilibrating solutions. In most cases, the dimeric anion became more prevalent as the pH of the equilibrating solution increased. Results were compared with data derived from potentiometric titrations and rationalized in terms of an electrostatically-based interpretation of polyelectrolyte and ion exchanger selectivities. Monomeric and chelated polymeric analogs of IMDA were also examined to compare directly the polyaminocarboxylate ligand in the chelated environment where dimerization is not possible to the free IMDA anion in equilibrating solution at various pH values.

**5494** (IS-Trans—94) **Physical-chemical properties of stoichiometric $La_2S_3$ monocrystals.** Kamarzin, A.A.; Sokolov, V.V.; Mironov, K.E.; Malovitskii, Yu.N.; Vasil'eva, I.G. Translated from *Mater. Res. Bull.;* 11: No. 6, 695-698(1976). 5p. Dep. NTIS $3.50.

Yellowish transparent single crystals of lanthanum sesquisulfide are prepared for the first time. They have no excess free metal and wet chemical analysis gave a composition of LaS/sub 1.500 +- 0.029/. Some physical properties of the material are given.

**5495 Prediction and correlation of the enthalpies of gas-phase ionic reactions.** Marks, A.P.; Drago, R.S. (Univ. of Illinois, Urbana). *Inorg. Chem.*; 15: No. 8, 1800-1807(Aug 1976).

In this article, an equation previously derived to predict the enthalpies of reactions of ionic acids and bases is tested. As predicted by theory, this new equation works better than the E and C equation for the large enthalpies associated with the interaction of ions but not as well for the smaller enthalpies associated with the interaction of neutral acids and bases. The D and O parameters obtained on the systems for combinations of ions are reasonable in terms of the derived relationship of these quantities in a molecular orbital model and our qualitative notions about the relative importance of ionic and covalent bonding in the resulting compounds. Parameters are also reported which enable one to predict the enthalpies associated with the combination of the corresponding atoms or radicals to produce the same compounds.

**5496 Crystal structure of zirconium monochloride. A novel phase containing metal—metal bonded sheets.** Adolphson, D.G.; Corbett, J.D. (Ames Lab., IA). *inorg. Chem.*; 15: No. 8, 1820-1823(Aug 1976).

Monocrystals of ZrCl were obtained by the reaction of $ZrCl_4$(g) with a large excess of electropolished Zr in a sealed tantalum tube under a 600-800°C gradient for 24 days. Integrated diffraction data were secured on an automated diffractometer using Mo Kα radiation. Systematic absences among 203 observed reflections together with tuned diffraction data established a C-centered monoclinic cell with a = 5.943 (6), b = 3.419 (3), c = 9.087 (18) A, $\beta$ = 102.5 (1)°, Z = 4. The structure was solved by standard Patterson and Fourier techniques to a conventional residual of 0.080 and R/sub w/ = 0.087. The structure contains homoatomic layers sequenced Cl-Zr-Zr-Cl so as to generate four-layer sheets, the layers and sheets being geometrically close to cubic close packed along [001]. The result is found to be within experimental error of a higher symmetry trigonal cell (Z = 6) with the rhombohedral space group R3m. The diffraction data were therefore converted, averaged, and refined utilizing 85 independent reflections, half as many positional parameters, and a = 3.424 (2), c = 26.57 (4) A to give R = 0.071 and R/sub w/ = 0.087. Distances are not statistically distinguishable in the two refinements; although the rhombohedral description is formally preferred, the real symmetry probably depends appreciably on the crystalline perfection in the [001] direction. Each zirconium atom has three neighbors in the adjacent sheet at 3.09 A (Pauling bond order of 0.5), six more in the same sheet at 3.42 A, and three chlorine atoms on the other side at 2.63 A. Weak chlorine-chlorine interactions between sheets at 3.61 A contrast with the strong metal-metal binding within the sheets; the former are presumably responsible for the graphitic properties and anisotropic conduction of the compound.

**5497 Sulfur dioxide bonding in four-coordinate complexes. Crystal and molecular structure of the toluene solvate of bis(sulfur dioxide)bis(triphenylphosphine)platinum.** Moody, D.C.; Ryan, R.R. (Los Alamos Scientific Lab., NM). *Inorg. Chem.*; 15: No. 8, 1823-1826(Aug 1976).

The crystal and molecular structure of the toluene solvate of bis(sulfur dioxide)bis(triphenylphosphine)platinum, $Pt(SO_2)_2(PPh_3)_2$-$C_7H_8$, has been determined at -63°C. The compound crystallizes in the space group $P2_1/c$ with a = 10.858 (3) A, b = 20.570 (6) A, c = 19.497 (6) A, and $\beta$ = 115.62 (2)° with rho/sub calcd/ = 1.59 g/cm³ for Z = 4 (MoKα¹ radiation, lambda 0.709 (30)A. The structure refined to an unweighted R value of 0.036 for 5592 reflections with I greater than 3 sigma(I). The coordination geometry around the platinum is best described as a severely distorted tetrahedron with P1-Pt-P2 and S1-Pt-S2 angles of 158.58 (6) and 106.33 (8)°, respectively. The angles are consistent with arguments relating to the relative $\pi$-acceptor strength of the two ligands. Both sulfur dioxide groups are pyramidal with the average angle between the M-S vectors and $SO_2$ planes being 119° and an average M-S distance of 2.43 A.

**5498 Chlorine atom abstraction reaction of dichloromethylchromium(III) ions with chromium(II). Kinetics and radiotracer determinations.** Espenson, J.H.; Leslie, J.P. II. (Iowa State Univ., Ames). *Inorg. Chem.*; 15: No. 8, 1886-1891(Aug 1976).

Reaction with $Cr^{2+}$ in aqueous $HClO_4$ converts the complex $CrCHCl_2^{2+}$ to $CrCH_2Cl^{2+}$, with accompanying formation of $Cr^{3+}$ and $CrCl^{2+}$ in equivalent amounts. Kinetic data indicate that the first and rate-limiting step (k = 0.016 dm³ mol⁻¹ s⁻¹, 25.1°C) is a bimolecular halogen atom abstraction reaction of $CrCHCl_2^{2+}$ and $Cr^{2+}$ forming $CrCl^{2+}$ and $CrCHCl^{2+}$. The latter intermediate, according to chromium-51 tracer results, rapidly exchanges with $Cr^{2+}$ via an intermediate $Cr_2CHCl^{4+}$, the latter subsequently being converted to $Cr^{3+}$ and $CrCH_2Cl^{2+}$ in a protonolysis step. The chemistry of these reactions is discussed, and reference is made to the observation of an intensely absorbing transient formed at lower [H⁺] (0.01-0.05 M), which is believed to be a nonproductive intermediate lying off the main reaction pathway. A mechanism to account for these observations is proposed.

**5499 Crystal structure of monoclinic sulfur.** Templeton, L.K.; Templeton, D.H.; Zalkin, A. (Univ. of California, Berkeley). *Inorg. Chem.*; 15: No. 8, 1999-2001(Aug 1976).

Precise parameters are reported for the structure of monoclinic sulfur, the form which is stable from 95°C to 115°C bond angles and distances are tabulated, and two graphical representations of the structure are provided. (DDA)

**5500 Calculation of Mossbauer paramagnetic relaxation spectra without the "White-Noise approximation".** Shenoy, G.K.; Dunlap, B.D.; Dattagupta, S.; Asch, L. (Argonne National Laboratory, Argonne, Illinois 60439). *Phys. Rev. Lett.*; 37: No. 9, 539-542(30 Aug 1976).

Theoretical expressions have been obtained for calculating Mossbauer paramagnetic relaxation line shapes without involving the "white-noise approximation." The relaxation matrix is shown to be dependent on the hyperfine parameters and linewidth in addition to the bath parameters. The theory is used to analyze the data for $Cs_2NaYbCl_6$ and obtain values for the mean-square dipolar field and the spin correlaton time. (AIP)

**5501 Pressure dependence of the proton NMR chemical shift in liquid water.** Linowski, J.W.; Liu, N.; Jonas, J. (Department of Chemistry, School of Chemical Sciences and Materials Research Laboratory, University of Illinois, Urbana, Illinois 61801). *J. Chem. Phys.*; 65: No. 8, 3383-3384(15 Oct 1976).

Measurements of the NMR proton chemical shift in liquid water are reported as a function of pressure (upto 4 kbar) at temperatures of 0degree, 20degree, 50degree and 100degreeC.(AIP)

## ISOTOPE EFFECTS

*REFER ALSO TO CITATION(S) 4557*

**5502** (COO—3498-26) **Fundamental studies in isotope chemistry. Progress report, 1 July 1975—30 June 1976.** Bigeleisen, J. (Rochester Univ., N.Y. (USA)). 1976. Contract E(11-1)-3498. 11p. Dep. NTIS $3.50.

During the past year the coupling between the translational and rotational potential energy in solid and liquid $CO_2$ was confirmed by measurements on the similar molecule $N_2O$. Vapor pressures of $^{15}N^{14}N^{16}O$, $^{14}N^{15}N^{16}O$, and $^{14}N^{14}N^{18}O$ have been measured over the range 143 to 182° in the solid and 182 to 219° in the liquid. The liquid data fulfill the requirement that the shift in the internal vibrational energies from the gas to condensed phase vanishes at the critical temperature. The temperature dependence of the internal zero point energy shift leads to a pseudo temperature independent term in the logarithm of the vapor pressure ratio. The results of these linear molecules form the basis for the calculation of the vapor pressures of all the isotopic species of OCS. $^{18}OCS$ is predicted to have a large translational-rotational coupling. The first measurements of the isotopic fractionation factors for two components in a solution have been made as a function of concentration in argon-krypton mixtures. The measurements cover the range from pure argon to pure krypton and extrapolate very well to our previous measurements on the pure components. The mean square force on Kr in an infinitely dilute solution of Ar has been found equal to the mean square force on Ar in an infinitely dilute solution in krypton.

**5503 Spectroscopic studies of hydrated cyano and cyano—halide complexes of platinum (starting materials for the preparation of one-dimensional conductors).** Ferraro, J.R.; Basile, L.J.; Williams, J.M. (Argonne National Laboratory, Chemistry Division, Argonne, Illinois 60439). *J. Chem. Phys.*; 65: No. 8, 3025-3029(15 Oct 1976).

Infrared studies from 4000—80 $cm^{-1}$ were conducted on various hydrates of cyano and cyano—halide complexes of Pt(II) and Pt(IV). Tentative assignments for the vibrations involving the Pt atom, and for the water modes, were made. The latter assignments were based on a comparison with deuterated salts. Comparisons of the results obtained for these starting materials used in the preparation of one-dimensional electrical conductors, with those of the conductors themselves are given. (AIP)

## ISOTOPE EXCHANGE AND ISOTOPE SEPARATION

*REFER ALSO TO CITATION(S) 6391*

**5504** (BM-RI—8054) **Isotopic purification of helium by differential distillation below the λ-point.** Tully, P.C. (Bureau of Mines, Washington, D.C. (USA)). 1975. 19p. Bureau of Mines, Washington, DC.

A differential distillation method is described for removing $^3He$ from $^4He$. Differential distillation at 4.2 to 1.6°K was used to reduce the $^3He$ in $^4He$ from about 200 to less than 1 ppB. The results from four stills ranging in size from 1 to 25 l are reported. The method has the potential to be adapted to commercial-scale separations.

**5505** (CONF-750989—P4, pp IV.254-IV.265) **Chromatographic measurement of isotopic hydrogen impurities in purified tritium.** Warner, D.K.; Kinard, C.; Bohl, D.R. (Monsanto Research Corp., Miamisburg, OH). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

A cryogenic gas chromatograph is described that was constructed for dedicated analysis of permanent gas and hydrogen isotopic impurities in tritium and deuterium-tritium mixtures. The operating characteristics of this instrument and some results are presented in order to introduce gas chromatography as an analytical technique for potential application to CTR technology situations that require accurate measurement of parts per million and higher levels of isotopic and permanent gas impurities in tritium, deuterium, or mixtures of the isotopes.

**5506 Separation of isotopes of selected divalent elements by ion exchange.** Lee, D.A. (Oak Ridge National Lab., Tenn. (USA)). *J. Inorg. Nucl. Chem.*; **38**: No. 1, 161-163(1976).

Separation factors were determined for beryllium ($^7Be$-$^9Be$), calcium ($^{46}Ca$-$^{47}Ca$), and cobalt ($^{58}Co$-$^{60}Co$) isotopes by ion exchange chromatography. Pairs of isotopes (one stable and one radioactive) were partially separated by ion exchange columns using the band elution technique. A combination of radioactive counting and microanalytical chemistry was used to assay the samples isotopically. The data were treated by the method of Glueckauf for the calculation of the separation factors.

## ORGANIC CHEMISTRY

**5507 Limitations of kinetic studies of catalytic reactions on a single-crystal surface at low pressures in a UHV system.** Steinbruchel, C.; Somorjai, G.A. (Materials and Molecular Research Division, Lawrence Berkeley Laboratory). *J. Vac. Sci. Technol.*; **13**: No. 6, 1162-1165(Nov 1976).

An analysis is presented of the kinetics of catalytic reactions occuring on a small area (~1 $cm^2$), single-crystal surface in an UHV system at low pressures ($10^{-8}$—$10^{-4}$ Torr). One can measure reaction probabilities as low as $10^{-4}$ under flow conditions and $10^{-7}$ under batch conditions. For the purpose of illustration two examples are given: hydrogenolysis of isobutane and dehydrogenation of cyclohexane on platinum surfaces. (AIP)

### CHEMICAL AND PHYSICOCHEMICAL PROPERTIES

*REFER ALSO TO CITATION(S) 4509, 4643, 5448, 5449, 5487, 5495, 5497, 5498, 5523*

**5508** (Y—2042) **Synthetic-pitch binders by autoclave polymerization of organics.** Smith, W.E.; Napier, B. Jr. (Oak Ridge Y-12 Plant, Tenn. (USA)). 28 Jun 1976. Contract W-7405-eng-26. 25p. Dep. NTIS $4.00.

Polymers prepared by autoclave heat treatment of simple hydrocarbons were evaluated as sources of synthetic pitches for use in fabricating composite carbons. Hydrocarbons included: indene, phenanthrene, triphenylbenzene, 1,4-diphenyl-1,3-butadiyne, and cinnamylideneindene. Autoclave temperatures and pressures were in the ranges of 340 to 515°C and 5 to 28 MPa, respectively. The more promising pitch materials were liquids or low-melting solids with coke yields of approximately 50 weight percent. Binary mixtures of organics were able to produce polymers and resulting carbons with properties that were correlated to the composition of the organic blend, thus allowing the controlled modification of properties.

**5509** (N—75-24446) Translated from *Riv. Combust.*; **25**: 502-508(1971). 14p. (NASA-TT-F—16276). NTIS $3.25.

The phenomenon of nuclear magnetic resonance (NMR) is explained, and the use of NMR spectra in the analysis of organic compounds is discussed. It is shown that the highest potential of NMR spectrometry is in the structural analysis of pure organic compounds; it can also be used to advantage in petroleum chemistry. Other applications of NMR spectrometry are included. (Author) (GRA)

**5510** (ORNL-tr—4198) **Catalytic hydrogenolysis of dibenzothiophene.** Urimoto, H.; Sakikawa, H. Translated by H. Kubota from *Sekiyu Gakkaishi*; **15**: No. 11, 926-931(1972). 11p. Dep. NTIS $3.50.

The hydrogenolysis reaction of dibenzothiophene over molybdenum sulfide, tungsten sulfide, cobalt sulfide, and nickel sulfide catalysts were studied by means of a batch method. From the experimental results, the following conclusions were obtained. (1) The hydrogenolysis activity was in the following order: molybdenum sulfide greater than tungsten sulfide greater than cobalt sulfide greater than nickel sulfide. (2) The formation reaction of biphenyl and the consecutive reaction in which hydrogenation and cracking proceed competitively occur simultaneously. (3) The hydrogenolysis activity of dibenzothiophene is varied by the amount of hydrogen sulfide which is related to the equilibrium of molybdenum disulfide and molybdenum trisulfide. (4) The active sites for the hydrogenation of the aromatic nucleus are different from the sites for the cleavage of c-s bond.

**5511** (ORNL-tr—4222) **Effect of some metal chlorides on the thermal decomposition of poly(vinyl chloride) and poly(vinylidene chloride).** Myakhov, V.N.; Troitskii, B.B. *Tr. Khim. Khim. Tekhnol.*; No. 1, 124-125(1973). 3p. Dep. NTIS $3.50.

In thermal decomposition of PVC, additions of $HgCl_2$ and $FeCl_3$ were found to be initiators of the thermal decomposition rather than catalysts. In the case of polyvinylidene chloride the metal chlorides acted as catalysts. (LK)

## ELECTROCHEMISTRY

**5512 Extension of a two-structure model for electrolyte solutions to aqueous mixed electrolyte systems.** Lietzke, M.H.; Stoughton, R.W. (Oak Ridge National Lab., TN). *J. Inorg. Nucl. Chem.*; **37**: No. 12, 2503-2506(Dec 1975).

A two-structure model for electrolyte solutions has been extended to the prediction of the activity coefficient of each component in a mixed electrolyte solution. Activity coefficients predicted using this model agree as well with fitted-observed values for a number of mixtures as those predicted using a model which retains a Debye—Hueckel term at all ionic strengths. The advantages of the two-structure model include: (1) fewer adjustable parameters are needed per component electrolyte; and (2) the fact that two of the parameters describing the ionic strength dependence of the activity coefficient of the component electrolytes seem to have direct physical origin.

## PHOTOCHEMISTRY

**5513 Energy capture in photosynthesis: Photosystem II.** Radmer, R.; Kok, B. (Martin Marietta Corp., Baltimore). *Annu. Rev. Biochem.*; **44**: 409-433(1975).

This review is limited to information pertaining to Photosynthesis II in the photochemical processes in which a weak reductant and a strong oxidant are formed. The strong oxidant indirectly oxidizes $H_2O$. Artificial donor and acceptor reactions and the effects of inhibitors are only briefly mentioned. The results of the kinetic experiments related to the oxygen evolution system are discussed in the first section of the review. Results related to the identity of the components involved in the overall process are discussed. The review is directed at describing and evaluating some of the data and hypotheses published since the last comprehensive review in 1970. 216 references. (BLM)

**5514 Photoreduction of the uranyl ion with argon laser light and ethanol. 3. The photochemical reduction of dioxouranium(VI) to dioxouranium(V).** Bell, J.T.; Billings, M.R. (Oak Ridge National Lab., Tenn. (USA)). *J. Inorg. Nucl. Chem.*; **37**: No. 12, 2529-2531(Dec 1975).

The photochemical reduction of $UO_2^{2+}$ to $UO_2^{+}$ with argon laser light and ethanol was studied at 25 and 45°C. Quantum yields for the reduction were determined to be near unity for each temperature, and the yields were compared with those for the photochemical reduction of $UO_2^{2+}$ to $U^{4+}$ under similar experimental conditions. The results of experiments designed to photochemically reduce $UO_2^{+}$ were inconclusive.

## RADIATION CHEMISTRY

*REFER ALSO TO CITATION(S) 5449, 5464*

**5515** (COO—3435-20) **EPR and optical spectroscopic studies of neutral free radicals in an adamantane matrix.** Jordan, J.E. (Pittsburgh Univ., Pa. (USA)). Mar 1975. Contract E(11-1)-3435. 134p. Dep. NTIS $6.00.

Thesis.

Recent work in our laboratory has demonstrated that neutral free radicals produced by x-irradiation and trapped in adamantane exhibit exceedingly long lifetimes because of the lack of rapid diffusion in the solid matrix. This observation and the fact that samples can be pressed into pellets with high optical transparency in the visible and near uv regions of the spectrum suggested to us that this unique matrix might be used for studying the optical properties of free radicals. The results of a wide variety of experiments of this type are described in this thesis. These include experiments in which secondary free radicals are produced by photoinduced decomposition of primary free radicals by selective irradiation with visible light, the observation of strong optical absorption spectra of free radicals at room temperature using a Cary 14 spectrophotometer, the finding that certain free radicals exhibit strong, visible fluorescence when irradiated with uv light, and the discovery that the absorption intensity of multiplicity-forbidden transition in singlet and doublet state species is enhanced relative to spin-allowed transitions by at least three orders of magnitude. An analysis of these results in terms of molecular orbital theory is given, and experiments designed to obtain the epr spectra of electronically-excited states of free radicals are described.

**5516** (AEC-tr—7533/9, pp 1-7) **Radiation-induced polymerization in the solid state. Part IV. The effect of oxygen on the yield of radiation polymerization of N-vinylcarbazole.** Pekala, W.; Lesinski, A. (Tech. Univ. of Lodz, Poland). Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

Radiation-induced polymerization of crystalline N-vinylcarbazole (NVC) was investigated in the presence and absence of air. The polymerization was studied in relation to dose and dose rate of $^{60}$Co γ-rays and to temperature within a range of 20 to 70°C. At 20° and 40°C, the rate of polymerization was found to be practically unaffected by oxygen present above the surface of the crystal monomer. At higher temperatures, the oxygen present in the reaction medium distinctly inhibits polymerization of liquid and solid NVC.

**5517** **Applied industrial radiation chemistry of monomers and polymers.** Hoffman, A.S. (Univ. of Washington, Seattle). pp 65-80 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

The latest trends in the application of radiation from radioisotopes or electron accelerators to the chemical processing of monomers and polymers will be highlighted. The chemical reactions involved in these processes are all free radical in nature and include monomer-monomer reactions (homo and co-polymerization), monomer-polymer reactions (graft copolymerization), and polymer-polymer reactions (crosslinking and chain scission). Processes and products to be covered are: wire and cable, foam, shrinkable film and molded objects, coatings, textiles, wood-plastic combinations, wood chips, solution-degraded polymers, and specialty grafted-polymer products as new biocompatible materials, enzyme reactors, membranes, etc.

**5518** **Radiation cured acrylonitrile—butadiene elastomers.** Eldred, R.J. (to General Motors Corp.). US Patent 3,950,238. 13 Apr 1976. Filed date 9 Aug 1974. 6p.

In accordance with a preferred embodiment of this invention, the ultimate elongation of an electron beam radiation cured acrylonitrile-butadiene elastomer is significantly increased by the incorporation of a preferred noncrosslinking monomer, glycidyl methacrylate, in combination with the conventional crosslinking monomer, trimethylolpropanetrimethacrylate, prior to the radiation curing process.

## RADIOCHEMISTRY AND NUCLEAR CHEMISTRY

### PROPERTIES OF RADIOACTIVE MATERIALS

*REFER ALSO TO CITATION(S) 4552, 4553, 4554, 4555, 4556, 4566, 4570, 4587, 5572*

**5519** (ARH-SA—207) **Kinetic study of the reaction of plutonium(IV) with hydroxylamine.** Barney, G.S. (Atlantic Richfield Hanford Co., Richland, Wash. (USA)). Mar 1975. Contract AT(45-1)-2130. 25p. (CONF-750410—12). Dep. NTIS $3.50.

From 169. national meeting, American Chemical Society; Philadelphia, Pennsylvania, USA (6 Apr 1975).

The kinetics of the one-equivalent reduction of plutonium(IV) with a large excess of hydroxylamine in nitric acid solution was studied. The form of the experimental rate law implies that a multi-step reaction mechanism is involved. Using the equilibrium-steady-state approximation, a rate law with the above form can be derived from a mechanism in which the reduction reaction rapidly approaches equilibrium with the reverse reaction. As this equilibrium is neared, the rate-controlling step becomes the dimerization of the $NH_2O$ radical intermediate to form $H_2N_2O_2$ which then decomposes to nitrogen gas and water. Measurements of initial reaction rates give results which are consistent with this mechanism. The values for k' and K/sub d/ (dissociation constant for $PuNO_3^{3+}$) at 30°C are 0.029 +- 0.008$M^5$ $sec^{-1}$ and 0.33 +- 0.15M, respectively. The apparent activation energy for the reaction is 31 +- 1 kcal/mole.

**5520** (PUB—97) **Early history of heavy isotope research at Berkeley, August 1940 to April 1942.** Seaborg, G.T. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). Jun 1976. Contract W-7405-Eng-48. 158p. Dep. NTIS $6.75.

A day-to-day account of the work done at Berkeley during August 1940 to April 1942 on the discovery of plutonium and on the isotope $^{233}$U is given. (LK)

**5521** (RFP-NUREG—2555) **Reference critical experiments. Progress report, April 1, 1976—June 30, 1976.** Schuske, C.L.; Dickinson, D.; Rothe, R.E. (Atomics International Div., Golden, Colo. (USA)). Aug 1976. Contract E(29-2)-3533. 29p. Dep. NTIS $4.00.

The greater part of our effort this quarter was the set-up and performance of twenty-four Task 4 critical experiments on minimally reflected tanks containing uranyl nitrate solution at an enrichment of approximately 93 percent and a range of concentrations. A detailed geometry description of the apparatus has been written and used to generate data for comparison with the experimental results. Preparation for the reflected single and multiple cylinder experiments continues. Two methods of preparing the low-enriched $U_3O_8$ at the desired density and H/U are being considered, and the results of these studies are given.

**5522** **High temperature spectroscopic and X-ray diffraction studies of californium tribomide: proof of thermal reduction to californium(II).** Young, J.P.; Sluis, K.L.V.; Werner, G.K. (Oak Ridge National Lab., Tenn. (USA)); Peterson, J.R.; Noe, M. *J. Inorg. Nucl. Chem.*; 37: No. 12, 2497-2501(Dec 1975).

Californium tribromide ($CfBr_3$) has been studied on the several microgram scale by spectroscopic and X-ray powder diffraction methods between 25°C and about 700°C. Spectroscopic evidence indicates that $CfBr_3$ undergoes reduction to produce Cf(II) in greater amounts with increasing temperature, with about 15 to 30 per cent reduction at 600°C. Despite the ingrowth of Cf(II) into the $CfBr_3$ with increasing temperature, all the powder diffraction patterns exhibited only the monoclinic $AlCl_3$-type structure characteristic of $CfBr_3$ confirming this structure type as the high-temperature one. A mechanism involving a reversible shift of electron density from the Br ions to the Cf(III) ions with temperature is postulated to explain satisfactorily the experimental observations made in the present and previous studies. Californium triiodide is predicted to undergo thermal reduction to Cf(II) more readily than $CfBr_3$.

**5523** **Crystal and molecular structures of thorium and uranium tetrakis(hexafluoroacetonylpyrazolide) complexes.** Volz, K.; Zalkin, A.; Templeton, D.H. (Univ. of California, Berkeley). *Inorg. Chem.*; 15: No. 8, 1827-1831(Aug 1976).

Triclinic crystals of thorium(IV) and uranium(IV) tetrakis(hexafluoroacetonylpyrazolide) are isostructural, with space group P1 and Z = 2. At 23°C for $Th(C_6H_3ON_2F_6)_4$ α = 11.282 (5) A, b = 16.245 (7) A, c = 10.836 (5) A, α = 90.14 (5)°, β = 108.75 (5)°, and γ = 107.07 (5)°. For the uranium compound a = 11.302 (5) A, b = 16.377 (8) A, c = 11.000 (5) A, α = 87.85 (5)°, β = 111.02 (5)°, and γ = 109.95 (5)°. X-ray diffraction data were measured with a scintillation counter, theta-2theta scans, and Mo Kα radiation. For thorium the conventional R value is 0.026 for 2966 unique data with I greater than sigma(I), and for uranium it is 0.027 for 4125 unique data with I greater than sigma(I). The full-matrix least-squares refinement of the 598 parameters of each structure included anisotropic thermal parameters for the 61 nonhydrogen atoms and isotropic ones for the 12 hydrogen atoms. The actinide ion is at the center of an irregular polyhedron of four oxygen and four nitrogen atoms. The average Th-O, Th-N, U-O, and U-N distances are 2.291 (4), 2.637 (5), 2.237 (3), and 2.574 (5) A. The molecules are packed in a manner which resembles cubic closest packing but which is more nearly analogous to the body-centered tetragonal structure of protactinium metal.

### RADIOISOTOPE PRODUCTION

**5524 Method of producing $^{123}I$.** Blue, J.W. (to National Aeronautics and Space Administration). US Patent 3,966,547. 29 Jun 1976. Filed date 13 Mar 1973. 4p.

Bombarding a cesium heat pipe with high energy particles causes a spallation reaction which produces vapors of $^{123}Xe$ and contaminants. The contaminants are removed in a dry ice cold trap while the $^{123}Xe$ condenses in a liquid nitrogen trap where it decays to $^{123}I$.

## COMBUSTION CHEMISTRY

*REFER ALSO TO CITATION(S) 4556*

**5525 Flame spread over an inclined thin fuel surface.** Kashiwagi, T.; Newman, D.L. (National Bureau of Standards, Washington, DC). *Combust. Flame;* **26**: No. 2, 163-177(Apr 1976).

Downward flame spread velocity over a thin $\alpha$-cellulose sheet was measured from the vertical to the horizontal positions under external radiant fluxes of 0, 0.9, 1.4, and 2.0 W/cm$^2$. The flame spread velocity had little dependency on the angle of inclination of the sheet with the stable lower flame. When the lower flame became unstable, wavy flames, cellular flames, and flame rolls were observed below the lower surface. With these unstable lower flames, the flame spread velocity increased significantly reaching several cm/s. Qualitative analysis based on the Rayleigh instability mechanism describes well the effects of the inclination angle and the external flux on the instability of the lower flame.

# ENGINEERING

## GENERAL ENGINEERING

**5526** (BDX—613-1392) **Gear cutting.** Stiles, R.W. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 80p. Dep. NTIS $5.00.

The activity on the project described was divided into three sections: grinding 120 pitch, 12 tooth pinion gears; shaping ratchet wheel teeth; and shaping fine pitch internal gear teeth. These activities were carried to provide new knowledge in the areas of gear cutting. The first activity involved grinding a miniature pinion gear. Bendix had been producing a functional miniature gear by hobbing, but the required surface finish was borderline and burrs on the part were difficult to remove. As a result of this project, a repeatable process was developed for grinding the tooth form and maintaining a 16 $\mu$in. AA (0.41 $\mu$m) surface finish with minimum burrs. The second area investigated was generation shaping ratchet wheel teeth. Because of disadvantages associated with other methods, gear shaping was studied as an alternate, more versatile method of making ratchet teeth. In gear cutting, the reciprocating action of the cutter permits cutting internal teeth and features that are closely banked against obstructions. In addition, irregular, segmented, noncircular, or interrupted configurations can be produced. Initial investigations, using the trial-and-error layout cutter design technique, were found to be too inaccurate for Bendix purposes. Therefore, a mathematical model and computer program were created that will accurately predict whether a desired ratchet tooth geometry can be produced, and will also design the cutting tool. The final activity was shaping internal gear teeth. The test data showed that the standard deviations for the high and low pitch diameters were 0.00036 and 0.00056 inch (9.1 and 14 $\mu$m) respectively and that the total composite error (TCE) had a standard deviation of 0.00051 inch (13 $\mu$m).

**5527** (BDX—613-1423) **Evaluation of loop and parallel oil channel designs.** Bruegge, D.C. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 28p. Dep. NTIS $4.00.

The study described was conducted as a part of process improvement for injection molding. The objective was to obtain thermal performance data for cyclic mold oil channel designs. Mold temperature control becomes more complex with faster responding cyclic molds. Unlike conventional constant-temperature molding, mold temperature cycling allows the injection into a mold of a plastic melt which is above the glass transition temperature of the polymer. Controlling the cooling of the mold and the plastic through its glass transition temperature results in a more stable molding with more repeatable dimensional criteria. During the course of this study, three oil channel designs were evaluated for temperature response and temperature uniformity. Two designs contained a single-channel looping arrangement, and the third design contained a series of five parallel channels, requiring a smaller number of loops and channel length to cover the same area. The significant effect of oil channel design was the influence on temperature uniformity. The parallel channel design had the smallest surface temperature variation for the same channel-to-surface distance. This is attributed to the significantly shorter channel length of this design, compared to the single channel loop design. At a 1.0 inch (25.4 mm) channel-to-surface distance, the single-channel loop design has a transient (mold temperature changing) temperature variation of 16°F (9°C), compared to 8°F (5°C) for the parallel channel design.

**5528** (BDX—613-1429) **Skiving. Final report.** Gillespie, L.K. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 35p. Dep. NTIS $4.00.

The production of low-quantity, high-precision shafts and cylindrical components is a time-consuming and expensive operation. Skiving, which involves the use of a form tool, can be a considerably faster operation than the traditional single-point turning. However, little has been published on the process. When the study described was initiated, no data was available on the tolerance capabilities or economics of skiving as a method for producing precision components. The objective therefore was to determine the tolerance capabilities of the process and the economics involved in its use. This was accomplished through an evaluation of tool geometry, repeatability, and resulting surface finish. Although skiving has been used primarily with screw machines, its applicability to chucking lathes was investigated in this study. Two typical shaft shapes were evaluated through the use of 303Se stainless steel. The investigation showed that skiving can maintain +-0.001 inch (25.4 $\mu$m) tolerances in 303Se stainless steel, although +-0.002 inch (50.8 $\mu$m) is more realistic. The latter value represents less-than-optimum cutting conditions. When time is available to experiment with tool geometry, the smaller tolerance can be held; usually, however, time is at a premium. Surface finishes of 32 microinches rms (0.81 $\mu$m), or less, were produced on 303Se stainless steel. In general, a 16-microinch rms (0.41 $\mu$m) finish on stainless steel represents a reasonable capability limit for the process. In some instances, better finishes can be produced. An analysis of the costs involved indicates that skiving becomes economical at length-to-diameter ratios of approximately 10:1.

## FACILITIES AND EQUIPMENT

*REFER ALSO TO CITATION(S) 5002*

**5529** (ORNL/NUREG/TM—33) **Apparatus for spot welding sheathed thermocouples to the inside of small-diameter tubes at precise locations.** Baucum, W.E.; Dial, R.E. (Oak Ridge National Lab., Tenn. (USA)). 28 Jun 1976. Contract W-7405-eng-26;NRC-INA-40-495-75. 18p. Dep. NTIS $4.00.

Equipment and procedures used to spot weld tantalum- or stainless-steel-sheathed thermocouples to the inside diameter of Zircaloy tubing to meet the requirements of the Multirod Burst Test (MRBT) Program at ORNL are described. Spot welding and oxide cleaning tools were fabricated to remove the oxide coating on the Zircaloy tubing at local areas and spot weld four thermocouples separated circumferentially by 90° at any axial distribution desired. It was found necessary to apply a nickel coating to stainless-steel-sheathed thermocouples to obtain acceptable welds. The material and shape of the inner electrode and resistance between inner and outer electrodes were found to be critical parameters in obtaining acceptable welds.

**5530 Technique for measurement of elastic constants by laser energy deposition.** Calder, C.A.; Wilcox, W.W. (Univ. of California, Livermore). *Rev. Sci. Instrum.;* **45**: No. 12, 1557-1559(Dec 1974).

A convenient experimental arrangement for the measurement of elastic material constants from specimens of circular or rectangular rods is presented. An ultrasonic pulse technique is applied using very short stress pulses produced by laser energy absorption from a Q-switched ruby laser.

### CRYOGENIC AND SUPERCONDUCTING EQUIPMENT AND DEVICES

*REFER ALSO TO CITATION(S) 5284, 5440, 6344, 6345, 6346, 6347, 6348, 6349, 6350, 6352*

**5531** (BNL—50498) **Superconducting devices at Brookhaven National Laboratory.** Dahl, P.F. (Brookhaven National Lab., Upton, N.Y. (USA)). Jan 1976. Contract E(30-1)-16. 33p. Dep. NTIS $4.00.

The various ongoing programs in applied superconductivity supported by BNL are summarized, including the development of high field ac and dc superconducting magnets for accelerators and other applications, of microwave deflecting cavities for high energy particle beam separators, and of cables for underground power transmission, and materials research on methods of fabricating new superconductors and on metallurgical properties affecting the performance of superconducting devices.

**5532 Advances in cryogenic engineering, volume 19.** Timmerhaus, K.D. (ed.). (Univ. of Colorado, Boulder). *Adv. Cryog. Eng.;* 19: (1974).

Individual items have been abstracted separately.

**5533 Review of superconducting magnetic systems for generating transverse magnetic fields.** Sytchev, V.V. (Inst. for High Temperature, Moscow). *Adv. Cryog. Eng.;* 19: 67-77(1974).

A review is presented about the superconducting magnet systems designed to generate transverse magnetic fields in a channel. Such systems are essential for MHD generators, for use as magnetic dipoles in elementary particle accelerators, for use in transport systems for charged particle beams, for some types of electric motors and generators. Some specific examples of superconducting devices are demonstrated.

**5534 Application of loss models to superconducting solenoids.** Broach, J.T.; Lee, W.D. (US Army Mobility Equipment Research and Development Center, Ft. Belvoir, VA). *Adv. Cryog. Eng.;* 19: 181-185(1974).

The power losses due to eddy currents caused by a time-varying self-field in a normally conducting solenoid are calculated. This presentation presents the results of an application of loss models to a particular configuration of multifilament superconductor. The eddy current loss model is compared separately to loss measurements made on a coil wound from commercial copper wire.

**5535 Analysis of cryogenic current leads with normal conductors and superconductors in parallel.** Gamble, B.B.; Smith, J.L. Jr.; Thullen, P. (General Electric Co., Schenectady, NY). *Adv. Cryog. Eng.;* 19: 193-199(1974).

Coolant requirement of a vacuum-insulated, vapor-cooled, cryogenic current lead is analyzed. It was concluded that there appears to be an advantage to running superconductors in parallel with normal conductors in cryogenic current leads for most applications. Most of the advantages are a result of the superconductor's ability to make the normally conducting length of lead independent of the physical length of the lead. This allows operation at high current-to-mass-flow ratios over a wide range of currents.

**5536 Pneumatically driven split-cycle cryogenic refrigerator.** Horn, S.B.; Lumpkin, M.E.; Walters, B.T. (US Army Night Vision Lab., Ft. Belvoir, VA). *Adv. Cryog. Eng.;* 19: 216-220(1974).

A valveless split-cycle cryogenic refrigerator with a remote cold heat is described. The refrigerator has demonstrated high efficiencies for a miniature cooler.

**5537 Differential thermal analysis apparatus for use at cryogenic temperatures.** Catalano, E.; Rinde, J.A.; English, J.C. (Univ. of California, Livermore). *Adv. Cryog. Eng.;* 19: 400-403(1974).

A novel differential thermal analysis (DTA) apparatus for use in the temperature range from 20 to 300 K has been constructed and put into operation. The apparatus has multiple sample cells for simultaneous testing of up to twelve samples. Both temperature control and data sampling are handled by a minicomputer using a modified version of an interpretive language. The DTA apparatus is used to measure and record any difference in temperature between a sample material and a reference cell. In this way, values for melting points, glass transition temperatures, solid--solid transitions, and approximate values for heats of fusion can be determined.

**5538 Design and selection of cryogenic heat exchangers.** Timmerhaus, K.D.; Schoenhals, R.J. (National Science Foundation, Washington, DC). *Adv. Cryog. Eng.;* 19: 445-462(1974).

An overview of the design and selection of current units for industrial cryogenics heat exchangers is presented. The main exchangers considered are of the coiled-tube type, plate-fin type, reversing and regenerator types.

**5539 An oscillating superleak sound transducer.** Tyler, A.; Vavasour, E. (Manchester Univ. (UK)). pp 234-237 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In recent years two types of sound transducer which use superleaks have been described. In this work an alternative method is proposed in which the superleak acts as both generator and detector of sound, and forms an integral part of the mechanical structure of a resonator which consists of two epoxy tubes enclosing a thin annular space, with the superleak across the section at one point. The resonator is driven by, an external torque, electrostatically to perform torsional oscillations and the resultant angular velocity is detected. The conditions for resonance are determined from the coupled equations of motion of the body and fluid in the annulus. In particular, resonators in which the superleak is a thin section of vycor glass, and the fluid is liquid helium-4 have been investigated.

**5540 Flicker (1/f) noise in Josephson tunnel junctions.** Clarke, J.; Hawkins, G. (Department of Physics, University of California, and Materials and Molecular Research Division, Lawrence Berkeley Laboratory, Berkeley, California 94720). *Phys. Rev., B;* 14: No. 7, 2826-2831(1 Oct 1976).

The power spectrum was measured of the voltage fluctuations in shunted Josephson junctions biased at a constant current I greater than the critical current I/sub c/. Over the frequency range $5 \times 10^{-2}$ to 50 Hz, the power spectra vary approximately as 1/f, where f is the frequency. At any single frequency, the noise decreases as I is increased. Experimental evidence is presented to show that the voltage noise arises from equilibrium fluctuations in the temperature T of the junction, which in turn modulate I/sub c/ and hence the voltage V across the junction. The magnitude of the power spectra is consistently predicted to within a factor of 5 by an extension of the semiempirical formula of Clarke and Voss: S/sub V/(f) = (dI/sub c//dT)$^2$(partialV/partiall/sub c/)$^2$/sub I/k/sub B/T$^2$ / 3C/sub V/f. In this formula, it is postulated that C/sub V/ is the heat capacity of an "effective" junction volume given by the product of the junction area and the sum of the coherence lengths of the two superconductors. The dependence of S/sub V/(f) on (partialV/partiall/sub C/)$^2$/sub I/ and (dI/sub c//dT)$^2$ is experimentally established.

## PROTECTIVE STRUCTURES AND EQUIPMENT

*REFER ALSO TO CITATION(S) 5092*

**5541 (CONF-760822—20) Effects of explosion-generated shock waves in ducts.** Busby, M.R.; Kahn, J.E.; Belk, J.P. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-eng-26. 11p. Dep. NTIS $3.50.

From 14. US ERDA air cleaning conference; Sun Valley, Idaho, United States of America (USA) (2 Aug 1976).

An explosion in a space causes an increase in temperature and pressure. To quantify the challenge that will be presented to essential components in a ventilation system, it is necessary to analyze the dynamics of a shock wave generated by an explosion, with attention directed to the propagation of such a wave in a duct. Using the equations of unsteady flow and shock tube theory, a theoretical model has been formulated to provide flow properties behind moving shock waves that have interacted with various changes in duct geometry. Empirical equations have been derived to calculate air pressure, temperature, Mach number, and velocity in a duct following an explosion.

## HANDLING EQUIPMENT AND PROCEDURES

**5542 (CONF-750989—P4, pp IV.133-IV.143) Scanning electron microscope facility for characterization of tritium containing materials.** Downs, G.L.; Tucker, P.A. (Monsanto Research Corp., Miamisburg, OH). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

A scanning electron microscope (SEM) facility for the examination of tritium-containing materials is operational at Mound Laboratory. The SEM is installed with the sample chamber incorporated as an integral part of an inert gas glovebox facility to enable easy handling of radioactive and pyrophoric materials. A standard SEM (ETEC Model B-1) was modified to meet dimensional, operational, and safety-related requirements. A glovebox was designed and fabricated which permitted access with the gloves to all parts of the SEM sample chamber to facilitate detector and accessory replacement and repairs. A separate console combining the electron optical column and specimen chamber was interfaced to the glovebox by a custom-made, neoprene bellows so that the vibrations normally associated with the blowers and pumps were damped. Photomicrographs of tritiated pyrophoric materials show the usefulness of this facility. Some of the difficulties involved in the investigation of these materials are also discussed.

**5543 History of fissile array measurements in the U.S. and comments on the current experiments program.** Schuske, C.L. (Rockwell International, Golden, CO). *Trans. Am. Nucl. Soc.;* **23**: 230(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5544 Monte Carlo method for array criticality calculations.** Dickinson, D. (Rockwell International, Golden, CO). *Trans. Am. Nucl. Soc.;* **23**: 230-232(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5545 Evaluation of criticality safety models used in interaction analysis.** Hunt, D.C. (Rockwell International, Golden, CO). *Trans. Am. Nucl. Soc.;* **23**: 232-233(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5546 Role of criticality models in ANSI Standards for nuclear criticality safety.** Thomas, J.T. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.;* **23**: 233-234(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5547 Effect of boron and gadolinium on the criticality of plutonium—uranium systems.** Lloyd, R.C.; Clayton, E.D. (Battelle Pacific Northwest Labs., Richland, WA). *Trans. Am. Nucl. Soc.;* **23**: 234-235(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5548 Critical experiments with low-moderated homogeneous mixtures of plutonium and uranium oxides containing 8 and 15 wt % plutonium.** Bierman, S.R.; Clayton, E.D. (Battelle Pacific Northwest Labs., Richland, WA). *Trans. Am. Nucl. Soc.;* **23**: 236-237(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

### SHIPPING CONTAINERS

**5549** (DPSPU—73-124-1(Suppl.1)) **Safety Analysis Report—packages: cobalt-60 shipping cask (packaging of radioactive and fissile materials). Final report.** Cherney, J.R.; Gates, A.A. (comps.). (Du Pont de Nemours (E.I.) and Co., Aiken, S.C. (USA). Savannah River Plant). Aug 1976. Contract AT(07-2)-1. 22p. Dep. NTIS $3.50.

Safety Analysis Report DPSPU 73-124-1 is revised to permit shipment of 8 slugs (max), each slug containing an average of 43,750 curies of $^{60}$Co and contained in a stainless steel can with a double-plug closure in cobalt-60 shipping casks in compliance with 10 CFR 71, Packaging of Radioactive Materials for Transport. This is in addition to the forms already discussed in DPSPU 73-124-1.

**5550 Radioactive material shipping container testing.** Bonzon, L.L. (Sandia Labs., Albuquerque, NM). *Trans. Am. Nucl. Soc.;* **23**: 92-93(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5551 Certification of packagings: compliance with DOT specification 7A performance requirements.** Edling, D.A.; Griffin, J.F. (Monsanto Research Corp., Miamisburg, OH). *Trans. Am. Nucl. Soc.;* **23**: 93(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## LASERS

*REFER ALSO TO CITATION(S) 6182, 6368, 6369*

**5552** (UCRL—13655) **Use of glass tape for cladding of glass laser discs. Summary report.** Johnson, B.E.; Bennett, R.B.; Niesz, D.E. (Battelle Columbus Labs., Ohio (USA)). 6 Aug 1975. Contract W-7405-eng-48. 28p. (SANL—385/005). Dep. NTIS $4.00.

For Univ. of California, Livermore.

It was proposed to demonstrate that a thick (greater than 0.060 inch) coating of cladding glass could be applied to an ED-2 laser glass disc by the "glass tape" technique. The feasibility of the approach was demonstrated by applying a 0.070-inch-thick coating of cladding glass to an "A"-size ED-2 laser glass disc. An existing cladding glass composition was used. Developing the equipment and technique required to bond the strip of cladding glass to the elliptical disc was a major part of the program. (MHR)

**5553** (UCRL—77739) **Crystal streak camera.** Thomas, S.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 16 Jul 1976. Contract W-7405-Eng-48. 8p. (CONF-760828—4). Dep. NTIS $3.50.

From 12. international congress on high speed photography; Toronto, Canada (1 Aug 1976).

A high speed optical deflection system has been designed for picosecond laser pulse diagnostics. Evaluation of a prototype system indicates that an ultracompact streak camera with picosecond resolution can be constructed from readily available components with a relatively low cost. A commercially available electro-optic beam deflector with a 2-mm aperture ADP crystal is used in the prototype. This unit is capable of deflecting wavelengths from the visible to 1.06 $\mu$m. When high power single picosecond pulses are used, previous limitations of electro-optic deflectors due to single beam absorption, internal heating, and mechanical shock waves are overcome. At 532 nm, a resolution of 18 spot diameters is obtained, while the dynamic range in excess of 200 is limited by the readout system. Use of a crystal material with a much higher electro-optic coefficient produces a theoretical resolution comparable to that of electro-optic cameras. The high current required to drive the crystal presents some difficult electronics problems and available solutions are discussed. Readout is accomplished with film, a TV camera, or a linear diode array. Computer manipulation of the output data can be used to improve resolution and dynamic range.

**5554** (UCRL—78514) **Analytical solutions for laser heating and burnthrough of opaque solid slabs.** Harrach, R.J. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 9 Aug 1976. Contract W-7405-eng-48. 24p. (CONF-760832—13). Dep. NTIS $3.50.

From 20. annual SPIE technical symposium; San Diego, California, United States of America (USA) (23 Aug 1976).

The thermal response of an opaque solid slab exposed to intense laser radiation is described using the heat-balance integral method. Approximate analytical solutions are obtained for the one-dimensional temperature distribution T(x,t), for the velocity x/sub s/(t) of the moving vapor-phase boundary, and for various derived quantities such as the front-surface vaporization time t/sub v/, the time to back-surface heating t/sub l/, and the sample burnthrough time t/sub BT/. Account is taken of the influence on t/sub l/ and t/sub BT/ of partial vaporization of the target material. The thermophysical properties of the target are assumed to be constant independent of temperature, but the theory accommodates a time-varying laser intensity and a temperature-dependent surface absorptivity. Illustrative burnthrough-time calculations are presented for aluminum, stainless steel, and carbon phenolic targets, covering a wide range of values of target thickness and laser intensity.

**5555 Review of high energy visible and uv lasers.** Hill, R.M.; Huestis, D.L.; Rhodes, C.K. pp 277-310 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

A review is given of the areas of atomic and molecular physics which will have the greatest impact on the development of high energy lasers. Pumping schemes and the prospects for a visible chemical laser to be of use for CTR are described. (MOW)

**5556 High power iodine lasers for fusion applications.** Gross, R.W.F. pp 311-367 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

The advantages of an iodine laser over solid state and gas lasers in laser fusion applications are discussed. An analysis is presented of a 100 TW single beam iodine laser in order to demonstrate its usefulness in controlled fusion research. (MOW)

**5557 From Maxwell to optical resonators.** Louisell, W.H. pp 369-485 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

A systematic development is given starting from Maxwell's equations of the paraxial approximation used in the differential equation approach. The stable oscillator modes in which diffraction is neglected are discussed, since they play an essential role in one adaptation of the differential equation approach to unstable resonators. The Fresnel—Kirchoff integral is introduced and the

paraxial approximation made. The lowest order "geometrical" mode for mirrors is obtained such that diffraction effects are neglected, using the integral equations. A model due to "Treacy" is presented in order to treat stable and unstable resonators with an active medium by the differential equation method. Finally, an alternate method of treating the unstable resonator by the differential equation approach is described in which saturation and diffraction effects can be included. (MHR)

**5558 Theory of a short wavelength swept-gain amplifier.** Bonifacio, R.; Hopf, F.; Meystre, P.; Scully, M. pp 487-556 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

The nature of amplification in a swept-gain laser is explored from first principles. It is shown that a number of anomalies can occur which are not found in the literature. (MHR)

**5559 Soft x-ray lasers pumped by photoionization.** Duguay, M.A. pp 557-579 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

One method proposed to pump an x-ray laser is based on the use of photoionization to selectively populate certain inner-shell vacancy states. The pumping requirements are calculable in a straightforward way. Calculations on a few typical examples are presented and the progress made at the experimental level is briefly reported. (MHR)

**5560 Optical frequency conversion in metal vapors.** Bloom, D.M. pp 631-649 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

Theoretical and experimental work, which has led to a number of new nonlinear optical devices utilizing third order nonlinearities in atomic vapors, is discussed. Third harmonic generation in alkali vapors has been demonstrated with conversion efficiencies as high as 10 percent and further improvements are predicted. Application to laser studies is discussed. (MHR)

**5561 Quasi-one-dimensional flame-sheet model for a cw diffusion chemical laser.** Stepanov, A.A.; Shcheglov, V.A. (P. N. Lebedev Physics Institute, Academy of Sciences of the USSR, Moscow). *Sov. Phys. - Tech. Phys. (Engl. Transl.)*; **21**: No. 3, 323-329(Mar 1976).

The flame-sheet model is extended to take accout of the thermal and gasdynamic effects of the flow. A phenomenologic model is constructed for calculations for diffusion lasers in the quasi-one-dimensional approximation. A simplified isothermal model for such a laser with both laminar and turbulent mixing of the streams is examined; the problem is solved analytically, with the multilevel structure of the radiating molecules taken into accout. The results can be used for rapid estimates of the energy parameters of cw diffusion chemical lasers. (AIP)

**5562 KrF-laser-pumped tunable dye laser in the ultraviolet.** Sutton, D.G.; Capelle, G.A. (The Aerospace Corporation, El Segundo, California 90245). *Appl. Phys. Lett.*; **29**: No. 9, 563-564(1 Nov 1976).

Tunable laser emission in the 335—346-nm region has been obtained from a 0.01M solution of p-terphenyl in p-dioxane. The dye laser was excited by a 20-nsec pulse from a Blumlein-driven KrF laser oscillating at 249 and 250 nm. (AIP)

**5563 New ion laser transitions in He-Au mixtures.** Reid, R.D.; McNeil, J.R.; Collins, G.J. (Department of Electrical Engineering, Colorado State University, Ft. Collins, Colorado 80523). *Appl. Phys. Lett.*; **29**: No. 10, 666-668(15 Nov 1976).

We have observed 20 new laser transitions when exciting a helium discharge in a gold-plated hollow cathode. The new ion laser transitions span the wavelength region from 253 to 763 nm. The behavior of laser power as a function of helium pressure and discharge current is presented. In general, the transitions have low threshold currents (<4 A), and the output power does not saturate at the limit of the discharge current. Multiline output power of 125 mW has been demonstrated in the 250—290-nm region. (AIP)

## HEAT TRANSFER AND FLUID FLOW

*REFER ALSO TO CITATION(S) 4827, 4984, 5037, 5132*

**5564 Exact solution of the Taylor instability problem.** Mahon Rao, P.K.; Andrews, D.G. (Univ. of Toronto). *Trans. Am. Nucl. Soc.*; **23**: 183

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5565 Transient heat transfer characteristics of liquid helium.** Tsukamoto, O.; Kobayashi, S. (Yokohama National Univ. (Japan). Faculty of Engineering). pp 305-308 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Studies on burnout (departure from nucleate boiling) heat fluxes of a stainless steel foil undergoing pulsive heating in saturated liquid helium at atmospheric pressure are reported.

**5566 Evaporation of the microlayer in hemispherical bubble growth in nucleate boiling of liquid metals.** Dwyer, O.E.; Hsu, C.J. (Brookhaven National Lab., Upton, N.Y. (USA)). *Int. J. Heat Mass Transfer*; **19**: No. 2, 185-192(Feb 1976).

A thermal analysis is used to estimate the extent of evaporation of the microlayer in hemispherical bubble growth in nucleate boiling of liquid metals on heated surfaces. As the bubble grows, evaporation of the microlayer produces a dry patch at its center whose size depends on the thermal and physical properties of the system, the roughness of the heating surface, and the boiling pressure. It was found that the area of this patch relative to that of the microlayer (or bubble base) is typically very small for liquid metals, and can be neglected in most theoretical analyses of bubble growth. It was further found that the loss of liquid from the microlayer due to evaporation into the bubble is at most a few percent, in a typical case. Since both the calculational model and mathematical analysis involve a number of simplifying assumptions, the numerical results of this pioneering study should be considered approximate.

**5567 Numerical simulation of wave propagation in two-phase flows.** Travis, J.R.; Hirt, C.W. (Los Alamos Scientific Lab., NM). *Trans. Am. Nucl. Soc.*; **23**: 191-192(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5568 Characteristic equations for a single-fluid model incorporating slip.** Tentner, A.; Weisman, J. (Univ. of Cincinnati). *Trans. Am. Nucl. Soc.*; **23**: 193-194(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**5569 Stationary solutions of the problem of Rayleigh—Taylor instability.** Pimbley, G.H. Jr. (Los Alamos Scientific Lab., NM). *J. Math. Anal. Appl.*; **55**: No. 1, 170-206(Jul 1976).

Previous experiments have established that when a light fluid is accelerated with a dense fluid in the direction of the latter, the plane interface is unstable, but when a dense fluid is accelerated with a light fluid in the direction of the latter, the plane interface is stable. An attempt is made to study the incompressible inviscid irrotational hydrodynamic problem, with variable interface, as a problem in nonlinear partial differential equations. (LCL)

## MATERIALS TESTING

*REFER ALSO TO CITATION(S) 4892, 5006, 5575, 5577*

**5570** (ORNL-tr—4145) **Ultrasonic pulse spectrometry.** (Bundesanstalt fuer Materialpruefung, Berlin (Germany, F.R.)). [nd]. Translated by R.G. Mansfield from the work study group 6.2, "Nondestructive testing" (Laboratory 6.24). 3p. Dep. NTIS $3.50.

Generally, it is required that nondestructive testing methods describe as accurately as possible the flaws found in a specimen by answering the questions: (1) where (2) what (3) how large and (4) how oriented. The ultrasonic echo method makes it possible to answer the first of these questions but not the other three. The application of ultrasonic pulse echo spectrometry is an attempt to make a closer approach to the answer to these three questions.

**5571 Digital enhancement of very low contrast radiographs.** Janney, D.H. (Los Alamos Scientific Lab., NM). *Mater. Eval.*; **34**: No. 8, 182-184(Aug 1976).

It is possible to enhance the visualization of obscure radiographic details by means of digital image enhancement. If the overall large-scale image density variations are removed by suppression of low spatial frequencies, smaller low contrast features may then be made readily visible with an extreme stretching of the image densities. Noise buildup is minimized with this procedure. An example using a radiograph of a weld defect is given.

## SAFETY ENGINEERING

*REFER ALSO TO CITATION(S) 4481, 4742*

**5572** (UCRL—78208) **Quality assurance for systems at the Lawrence Livermore Laboratory tritium facility.** Dow, J.P. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 20 May 1976. Contract W-7405-ENG-48. 21p. (CONF-761101—3). Dep. NTIS $3.50.

From 24. conference on remote systems technology; Washington, District of Columbia, United States of America (USA) (14 Nov 1976).

A quality-assurance program for tritium-handling systems at the Lawrence Livermore Laboratory tritium facility has been developed. Operational guidelines governing system design, construction, and testing have been written. A certified-material storeroom has been established to procure and distribute high-quality materials. Ten systems are currently being modified under the new guidelines.

## ELECTRONIC CIRCUITS AND DEVICES

*REFER ALSO TO CITATION(S) 4747*

**5573** (BDX—613-315) **Rework of multilayer printed wiring board assemblies.** Clement, D.W. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 41p. Dep. NTIS $4.00.

Processes of reworking printed wiring assemblies (PWA) built with multilayer printed wiring boards (MLPWB) were investigated. Because of the MLPWBs added thickness and increased heat absorption potential, assemblies built with these boards are suspected of being more susceptible to damage during component removal than assemblies built with single-layer double-sided boards. There also have been questions raised about the effect that rework has on the internal connections of the MLPWBs. A review and limited evaluation of all known rework methods resulted in selecting "solder wick" and "vacuum extraction" as the two main rework methods for use in the evaluations. The Appendix defines and describes these rework techniques. Two different groups of units, intended to be representative of a wide range of proposed and presently used MLPWB-component configurations, were fabricated and then reworked by variations of these two techniques. Approximately 16,000 internal connections of MLPWBs were subjected to rework. No internal connections became open or degraded. In addition, 80 PTHs with internal connections were subjected to 10 cycles of rework to examine the effect of rework on MLPWB internal connections. Continuity of the internal connections was measured before and after all rework. Even though the rework did cause extensive external damage to the MLPWBs (blisters, measles, and land damage, for example), there was no indication of internal connection degradation. The information received thus far leads to the conclusion that internal connections of MLPWBs are not likely to be degraded as a result of assembly rework.

**5574** (BDX—613-1187) **Rapid visual scanning.** Taylor, R.D. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 41p. Dep. NTIS $4.00.

A description is given of improvements in equipment and inspection techniques for visual inspection of electronic component assemblies. Comparison devices for enhancing differences between a master and test parts are evaluated. Illumination methods and television inspection developments were investigated. Indexing devices were evaluated and improved optical systems and methods were developed. An effective low-cost television comparison system was built; this system uses techniques such as blinking and subtraction for detecting differences in printed circuit boards. A glare-free illumination system called omnidirectional illumination was also developed and tested. This system reduces eyestrain, and performs very well on all types of surfaces and especially well on highly polished substrates. A low-cost manual indexing system called the Pantograph was designed and tested for quick, precise positioning of small circuit boards. The ultimate inspection system is one in which the inspector is an equipment operator instead of a decision maker. This is the reason for development of an automated comparison system. In this system, a PDP-11 computer controls a digital scanner and software was developed to monitor subtraction, hole location and size, path width, texture analysis, missing components, and feature analysis.

**5575** (BDX—613-1190(Rev.)) **Nondestructive testing of welded electrical connectors.** Cooper, E.B. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 22p. Dep. NTIS $3.50.

A description is given of a project to develop a nondestructive inspection technology for welded electrical connections. Emphasis was on percussive arc welds. While inspection of piece parts was the primary goal, nondestructive inspection of special samples used to control production also was considered. During the early phases of the project, efforts were entirely directed toward establishing a correlation between data from nondestructive tests and the tensile load required to break the weld. Later work confirmed that the ultrasonic pulse echo pattern of a percussive arc weld was changed when the weld schedule was changed. This technique discriminated between samples made by different schedules with better than 99 percent reliability. The finding that ultrasonic pulse echo techniques correlated with weld schedule parameters such as arc time and peak current prompted re-investigation of previously studied NDT techniques. The average infrared emission from several samples of the same schedule was also found to correlate with schedule information. During a brief search for alternative destructive tests, it was found that a 30 g vibration test at the resonance frequency of the welded sample showed promise. This test showed good capability for discriminating between weld schedules and always resulted in failures of the weld, not the wire.

**5576** (BDX—613-1205(Rev.)) **Evaluation of syntactic polysulfide stress relief coatings.** Neet, T.E. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 28p. Dep. NTIS $4.00.

The effect of phenolic microballoons on the pot life of syntactic polysulfide was evaluated. Material formulations and processing parameters were studied to develop procedures for applying a stress relief coating on electrical components to adequately protect these assemblies from stresses applied by the glass microballoon-filled encapsulating material. The static stress-strain as well as the bulk modulus characteristics of the syntactic polysulfide were evaluated. Cure schedules for the polysulfide were investigated.

**5577** (BDX—613-1245(Rev.)) **Accuracy of weight method used to determine aluminum foil thickness.** Lippert, M.C. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 22p. Dep. NTIS $3.50.

The performance of circuits produced by etching a pattern in thin aluminum foil bonded to a Mylar substrate depends on the uniformity of that aluminum foil. One method of determining this uniformity is to calculate the foil thickness from a specimen's weight and area. This technique has been used for several years to report foil thickness variations on nonplanar laminates, but the accuracy of the reported values had never been established. To determine this accuracy, the errors resulting from limits on the accuracy of the reported density value, the weighing technique, and the technique of determining specimen area were investigated. After these errors were determined, sample calculations were performed which showed how each of these expected errors affected the thickness value of the foil. Additional calculations showed that the worst case combinations of these errors produces a maximum variation of +-3 microinches (76.2 nm) in the calculated thickness value, while substitution of these individual errors into the statistically derived equation for the variance of a function of several random variables reveals an expected error of +-1 microinch (25.4 nm) in the calculated thickness value.

**5578** (BDX—613-1257) **Hybrid microcircuit intraconnection processes.** Bonham, H.B. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 84p. Dep. NTIS $5.00.

Hybrid intraconnections join thin film networks and applique components into an electrically functional hybrid microcircuit (HMC). Applique components were intraconnected with thermocompression (TC) bonds to chromium/gold metallized thin film networks. The project determined critical processes, material parameters, quality criteria, and characterization techniques. The program began on July 1, 1970, and initial efforts consisted of organizing the development program and forecasting needed equipment and manpower. The total time schedule was then PERT-charted. Gold beam-lead devices, gold wire, and chromium/gold films had already been selected for these intraconnection technologies. Thermocompression bonding was developed to provide intraconnections between the HMC gold conductor metallization and gold beam-lead active devices, gold plated external leads, and gold terminated applique devices, such as capacitors. An optimum combination of bonding parameters based on the fundamental physics of the process was developed. This philosophy required bonding equipment to be thoroughly characterized so that the value of bonding parameters (such as force and temperature) indicated on the bonder could be translated into measurable values of the force and temperature within the bond zone.

**5579** (BDX—613-1275) **Beam lead device temperature testing.** Brown, L.W. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 30p. Dep. NTIS $4.00.

The ability to perform 100-percent electrical probe testing of beam lead devices (BLD) at temperatures from 0 to 50°C was developed. Correlation of probe test results to bonded sample test results from —55 to 100°C was established for some parameters on transistors, diodes, and Zener diodes. The tests performed on transistors included collector-to-emitter leakage, collector-to-base leakage, current gain, and collector-emitter saturation voltages. Reverse leakage current tests were performed on diodes and Zener diodes in addition to forward voltage drop on diodes and Zener voltage on Zener diodes. It was determined from these tests that, in nearly all cases, probe testing can be performed at room temperature to assure a limit at temperature extremes once the exact temperature dependence of the parameter is known for a lot of devices. No waxes compatible with either vendor or Bendix Kansas City Division BLD processing are presently available which will allow testing at temperatures above 50°C.

**5580** (BDX—613-1288) **Photoresist application by roller coating.** Schantz, L.E. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 68p. Dep. NTIS $4.50.

Roller coating of AZ1350J photoresist onto 3.75- by 4.5-inch (95 by 114 mm) substrates was investigated as an integral part of an overall, cost-effective hybrid microcircuit (HMC) photolithography process. This process involved making several HMCs on a single substrate and was accordingly termed Multiple HMC Processing. New equipment was needed to process these multiple HMCs with sufficient parameter control to achieve the designed electrical characteristics. The roller coater study centered around the investigation and the control of those parameters which influence the dimensional quality of the thin-film, resistor-conductor pattern. General system operation, orientation to other processing equipment, and maintenance-facility considerations were also studied. The most important technical aspect of the photoresist coating is the thickness uniformity followed by the overall photoresist thickness. Three equipment variables: doctor bar pressure, roller/substrate interference, and roller thread configuration were found to control the overall resist thickness and thickness uniformity. Photoresist viscosity was also identified, with its relation to the roller thread configuration, to control the thickness and thickness uniformity.

**5581** (BDX—613-1346) **Interconnection technology.** Beck, W.P.; Sim, J.R. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 60p. Dep. NTIS $4.50.

A project was conducted to develop interconnection techniques for application to present and future electronic assemblies—especially those using hybrid microcircuits (HMCs). Project work included: (1) determination of the relative costs of welding opposed to the soldering of HMC packages; (2) evaluation of the solderability of thin films including definition of solderability tests; (3) establishment of a thermocompression (TC) bonding schedule to attach gold plated copper leads to thin film gold conductors; (4) determination of relative assembly times for Ampere sockets and bifurcated terminals to interconnect ceramic substrates; (5) determination of a means of interconnecting stacked, open-faced substrates within tight packaging restraints and demonstrating its feasibility by fabricating a model; (6) evaluation of a flexible circuit to replace a problem printed circuit board for enhancement of visual inspection of solder joints; and (7) development of a process to reflow solder, in a single operation, all or half of the ribbon leads from an integrated circuit (IC) or HMC package to a printed circuit board (PCB).

**5582** (BDX—613-1349) **Sandia/Bendix standard process capability study of printed wiring boards.** Wilson, J.L.; Jennings, C.W. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 62p. Dep. NTIS $4.50.

With the development of the SL/BX standard process for the manufacture of printed wiring boards, it was determined that a formal capability study should be undertaken. Work on the project began in May 1972. Manufacturing efforts in both production and the Engineering Shop were completed by July 1973. Ten lots of boards (252) were manufactured in the Bendix production department. One lot of boards (24) was manufactured in the Bendix Engineering Shop. Upon completion of inspection by Bendix, all boards were shipped to Sandia Albuquerque for further inspection and testing. Final inspection results of the 276 boards manufactured show the defects to be predominantly of a visual type. A total of 45 defective boards were found, for a 16 percent defective ratio. Of the 16 percent defective boards, 9 percent (26 boards) are considered nonfunctional and would result in scrap. The remaining 7 percent (19 boards) are considered functional but would require deviation. As a result of this study, the conclusion was reached that the Bendix production and Engineering Shop departments have the capability for producing printed wiring boards within the requirements of the SL/BX standard process and related specifications.

**5583** (BDX—613-1369(Rev.)) **Computer aided failure analysis.** Clement, D.W. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 20p. Dep. NTIS $3.50.

The manual processes commonly used to locate defects in electronic assemblies are often slow, inefficient, and costly. In addition to the actual failure analysis effort, a significant amount of engineering manpower must be used to train and assist troubleshooting personnel. When there is a change in personnel the training must be repeated. A project is described to develop an automated failure analysis process which will reduce the costs and eliminate some of the problems associated with present troubleshooting procedures. A computer aided failure analysis (CAFA) system, which uses the computer equipment in the Data Acquisition System, was designed for use on this project. The CAFA system is being developed for a specific application; however, the facilities and techniques are adaptable to many different product types. The system approach is to store a diagnostic analysis program in a centralized computer and activate the program through time share operation (TSO) terminals located in the manufacturing area. Automated fault isolation is accomplished by a question and answer communication between the computer and the troubleshooter. The computer asks questions about the test data and circuit performance to direct the troubleshooter to perform additional tests and checks. Ultimately, after guiding the troubleshooter through an analysis channel, the diagnostic program will decide on possible causes of failure. All statements and questions are presented to the user in English and all questions can be answered simply by typing a number into the TSO terminal.

**5584** (BDX—613-1371(Rev.)) **Memory assembly to hybrid microcircuits.** Kirk, W.J. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 17p. Dep. NTIS $3.50.

A memory module consists of a wired array of ferrite cores bonded and soldered to a hybrid microcircuit (HMC). The HMC is shipped to the memory plane supplier, where it is attached to the memory plane and returned. By developing suitable manufacturing processes, the need to ship the HMC to the memory supplier can be eliminated and material control problems can be simplified. A process is described that will allow Bendix to do all memory assembly work except stringing the core array: (1) a controlled process that relies more on programmed soldering machine instructions and less on operator variables was developed to produce repeatable solder joints. A key to this process was producing well-tinned magnet wires prior to making the solder joint; (2) a process was developed to bond memory planes to HMCs with an epoxy sheet adhesive; (3) a thin polyurethane coating can be selectively applied to solder joints with a very fine 5/0 artist's brush. The work must be done under a microscope; and (4) a method of testing the memory plane on existing equipment and a cause-of-failure test matrix for the completed module were developed. Restringing defective memory planes at Bendix is feasible, but additional development will be required. The reliability of machine soldered joints should be determined by subjecting properly soldered memory modules to an extensive thermal cycling evaluation.

**5585** (BDX—613-1376(Rev.)) **Ultrasonically welding electric terminals.** Darner, G.S. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 19p. Dep. NTIS $3.50.

The ultrasonic welding of electrical terminations was investigated for use on foil conductor terminations. Cleaning, surface finish, and plating were evaluated to determine their effects on ultrasonic weldability. The external application of heat was studied to observe any improvement in material weldability. Capabilities were established for welding two circuit layers separated by Mylar insulation and for terminating aluminum conductors to connector hardware.

**5586** (BDX—613-1404(Rev.)) **Equipment evaluations and process techniques for drag soldering printed wiring assemblies.** Morris, R.S. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 45p. Dep. NTIS $4.00.

Equipment was evaluated and various techniques were investigated for applying automated drag soldering to printed wiring assemblies. The activity centered on the adaptability of the equipment and techniques to densely packaged, low quantity, and high reliability products.

**5587** (BDX—613-1453) **Induction soldering evaluation.** Friebe, E.R. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 45p. Dep. NTIS $4.00.

A project is described which began in support of process development work on cables which use electromagnetic radiation (EMR) hardware. These cables require an air tight conductive

path between the shield, the adaptor ring, and the connector shell. Solder joint processing between the adaptor ring and connector involves installing a solder preform in the groove between ring and connector and inserting the connector in an induction heated work coil to melt the solder. A typical heat cycle lasts approximately 5 seconds and generates a peak temperature of about 500°F. The solder melts and flows into the threaded areas, making visual verification of the solder joint difficult. This investigation measured the temperature difference across the RTV seal in the connector and determined the extent of seal damage from heat. This investigation also determined the effects of subjecting the connector to a 600°F peak temperature. Seven work coils were evaluated and a coil was produced which will make a consistently air tight solder joint while minimizing heat transfer to the connector seal. A process and induction heating coil were developed to solder EMR hardware to the adaptor ring while minimizing heat transfer to previously soldered terminations.

**5588** (BDX—613-1456) **Failure modes of beam lead semiconductors in thin film hybrid microcircuits.** Swafford, J.H. (Bendix Corp., Kansas City, Mo. (USA)). 1975. Contract E(29-1)-613. 10p. (CONF-751010—3). Dep. NTIS $3.50.

From International microelectronics symposium; Orlando, Florida, USA (29 Oct 1975).

Beam lead semiconductor and passive devices have recently been utilized in hybrid microcircuits to provide higher reliability. This is derived from the beam lead device's improved bonding integrity plus the silicon nitride coating which reduces sensitivity to contaminants; however, their size requires special handling techniques to prevent handling damage. Other failure modes exist, such as cracked nitride, pinholes in the nitride, inadequate plating, and smeared metalization. After two years of production usage totaling approximately 150,000 devices, The Bendix Corporation's Kansas City Division has compiled significant data on beam lead devices including small signal, and power, discrete semiconductors and digital integrated circuits. These failure modes are characterized, and precautionary measures are described to minimize failures in HMC usage.

**5589** (BDX—613-1461) **Hand punching holes in unfired 99.5 percent alumina substrates.** Blessner, P.L. (Bendix Corp., Kansas City, Mo. (USA)). Aug 1976. Contract E(29-1)-613. 28p. Dep. NTIS $4.00.

The tooling and process techniques for hand-punching holes in green (unfired) 99.5 percent alumina ceramic substrates were investigated to determine the requirements for obtaining holes with good surface finish and a minimum number of defects. Such holes are needed to provide low electrical resistance ground paths from frontside to backside of vacuum-metallized ceramic substrates used to manufacture hybrid microcircuits. It was determined that holes having excellent surface finish and maximum via resistance of 9 mΩ (with a 6 μm surface thickness of chromium/gold metallization) could be obtained with the following processing and tooling: use heat-treated drill bushings to line the template holes; use a conical-tipped punch; use oil as a lubricant; spin the punch approximately five revolutions during the punching operation; and blow compressed air through the hole after punching. The as-fired hole diameter should be approximately 78 percent of the nominal punch diameter.

**5590** (BDX—613-1524) **Wiggly phase shifters and directional couplers for radio frequency hybrid microcircuit applications.** Taylor, J.L.; Prigel, D.D. (Bendix Corp., Kansas City, Mo. (USA)). Apr 1976. Contract E(29-1)-613. 9p. (CONF-760414—6). Dep. NTIS $3.50.

From Electronics components conference; San Francisco, California, United States of America (USA) (Apr 1976).

Packaging microwave hybrid microcircuits having combined electrical functions presented challenges in meeting space requirements without excessive signal interaction between microwave networks. The dispersive characteristics of microwave hybrid microcircuits are aggravated by the proximity of conductive materials, which places stringent requirements on packaging space and geometry. A space savings of 15 to 20 percent has been achieved with the wiggly phase shifter and wiggly directional coupler. In addition, the performance of each device has been significantly improved. The VSWR bandwidth of the phase shifter has been doubled, and the directivity of the directional coupler has been increased by 20 dB.

**5591** (BDX—613-1532) **Manufacturing processes for hybrid microcircuits containing vias.** Norwood, D.; Laudel, A.; Blessner, P. (Bendix Corp., Kansas City, Mo. (USA)). 1976. Contract E(29-1)-613. 15p. (CONF-760414—5). Dep. NTIS $3.50.

From Electronics components conference; San Francisco, California, United States of America (USA) (Apr 1976).

Hybrid microcircuits designed for ERDA by Sandia Laboratories require metallized vias to interconnect frontside tantalum-nitride, chromium-gold thin-film networks with metallized backside ground planes on 3.75 in. (95.2 mm) by 4.5 in. (114 mm) alumina substrates. Manufacturing processes were developed for making holes in alumina substrates, metallizing substrates on both sides and through vias, dry film photolithographing 6 μm thick gold to 5 mil (127 μm) line widths and spacing, and determining via quality and acceptance. The techniques developed produced vias with low resistance characteristics. Vias have been produced which exhibit through-hole resistances of less than 10 mΩ and are acceptable for radio frequency or logic circuit application. Sample parts have been fabricated and evaluated on both test substrates and production substrates to prove-in the new techniques. An orbital planetary system which metallizes substrates on both sides and through the vias simultaneously is now being characterized.

**5592** (BDX—613-1535) **Production coating of vias in alumina substrates with vacuum evaporated chromium and gold.** Losure, J.A. (Bendix Corp., Kansas City, Mo. (USA)). 1976. Contract E(29-1)-613. 10p. (CONF-760414—3). Dep. NTIS $3.50.

From Electronics components conference; San Francisco, California, United States of America (USA) (Apr 1976).

Design of a production vacuum deposition fixture for coating 3.75 in. by 4.50 in. (95 by 114 mm) alumina substrates with 50 nm of chromium and 6 μm of gold presented challenges in meeting geometry, mechanical, and cost constraints. The coated substrates had to meet unique requirements for via resistance, thickness uniformity, and backside metallization on hybrid microcircuits. The design required that vacuum evaporated chromium and gold thin films be used with a thru-hole maximum resistance of 25 milliohms on 0.025-in.-dia (0.64 mm) vias in 0.027-in.-thick (0.69 mm) alumina substrates. A resistance of 10 milliohms was a highly desirable design objective. It was also highly desirable to coat both sides of the substrate and the via walls with chromium before depositing the gold rather than depositing the chromium and the gold on one side of the substrate and then turning the substrate over to deposit the chromium and gold on the other side. Depositing both the chromium and gold on one side of the substrate at a time would result in a layered chromium-gold-chromium-gold structure on the via wall. Commercially available planetary fixtures could not deposit films which met all the design objectives. A study of fixture geometry versus the required film characteristics resulted in the design of a fixture which rotates the substrates 360 degrees about their long axis while simultaneously rotating them about the deposition source in a prolate cycloid motion.

**5593** (BDX—613-1536) **Handling automation and temperature control added to transistor s-parameter measurement.** Markley, R.E. (Bendix Corp., Kansas City, Mo. (USA)). 1976. Contract E(29-1)-613. 7p. (CONF-760414—4). Dep. NTIS $3.50.

From Electronics components conference; San Francisco, California, United States of America (USA) (Apr 1976).

No method is known in industry which permits automatic handling and contacting in preparation for s-parameter measurement of large quantities of rf small signal transistors. Typically, transistors are measured by manually loading each device into an rf test fixture which serves to connect the device to the rf test equipment ports. The fixture is opened after the test and the device is manually unloaded. This method, while satisfactory for testing small quantities of devices in a laboratory environment, is slow and tedious in a production environment. In addition, this method precludes s-parameter measurements at non-ambient temperatures. A handling/contacting mechanism was developed that consists of rf carriers, an rf contactor, and a chamber, which can be used to increase the testing thruput of small signal transistors. The s-parameters of many transistors can be measured rapidly in the 0.5 GHz to 2.0 GHz range and in a temperature-controlled environment of −55 to 125°C. Additionally, non-rf device testing such as high temperature reverse bias (up to 200°C), burn-in, dc parameter measurements (−55 to 125°C), and junction capacitance measurements, may all be conducted without removing the transistors from the rf carriers.

**5594** (UCRL—77548(Rev.1)) **Analytic technique for router comparison.** Wilson, D.C.; Smith, R.J. II. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 16 Apr 1976. Contract W-7405-eng-48. 10p. (CONF-760609—9). Dep. NTIS $3.50.

From 13. design automation conference; Palo Alto, California, United States of America (USA) (27 Jun 1976).

A model is introduced for printed circuit boards which can be used to predict the probability that a router will successfully make a connection. The model reflects certain characteristics of the circuit board that is being routed and the model incrementally changes as the board is routed. Routing procedures typically have certain parameters which influence selection of the set of paths

that are explored, and determine the order of exploration. These parameters obviously influence the probability that a particular connection can be made. These parameters may also be used to formulate a model of the behavior of a particular routing procedure.

## SOLID WASTE PROCESSING PLANTS AND EQUIPMENT

*REFER ALSO TO CITATION(S) 4456*

## COMBUSTION SYSTEMS

*REFER ALSO TO CITATION(S) 4745*

# PARTICLE ACCELERATORS

## DESIGN, DEVELOPMENT, AND OPERATION

**5595** (ERDA—1548) **Intense Neutron Source facility, Los Alamos Scientific Laboratory, Los Alamos, New Mexico. Final Environmental Statement.** (Energy Research and Development Administration, Washington, D.C. (USA)). Jul 1976. vp. Dep. NTIS $9.25.

A final environmental statement is presented which was prepared toward compliance with the National Environmental Policy Act and in support of the Energy Research and Development Administration's proposed actions to construct and operate a deuterium-tritium gas target intense neutron source at the Los Alamos Scientific Laboratory (LASL) in Los Alamos, Los Alamos County, New Mexico. The purpose of the proposed facility is to provide an experimental neutron irradiation facility providing a neutronic environment similar to that anticipated in a fusion power reactor. In addition, the facility will provide prototypic testing of tritium pumping, purification, containment, and cleanup systems necessary for future experimental power reactors. The benefits of developing radiation resistant structural materials, insulators, and tritium handling systems suitable for use in fusion reactors would be substantial and far outweigh the nominal environmental impacts associated with construction and operation of this facility. The principal environmental impacts of the proposed facility result from routine construction activities including clearing approximately six acres of land for the building, parking areas and an access road. Liquid waste discharges consist primarily of cooling tower blowdown during operations. Significantly contaminated liquid and solid waste will be disposed at the existing LASL waste disposal area. Very small quantities (less than 100 curies per year) of tritium and traces of other radioactivity will result in site boundary doses not exceeding 5 mrem per year, or less than 5 percent of applicable radiation protection guidelines and less than 5 percent of the natural radiation background from naturally occurring radioactivity. Alternatives considered included abandoning or postponing the project, selecting alternative designs, and selecting alternative locations for the facility.

**5596** **Skyshine: a paper tiger.** Rindi, A.; Thomas, R.H. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). *Part. Accel.*; 7: No. 1, 23-39(1975).

The study of large-distance transport of high-energy accelerator radiation is of fundamental interest and is important in the calculation of the exposure of the population living near the accelerator. The most significant experimental data accumulated since the construction of the early particle accelerators and their theoretical interpretation are reviewed.

## BEAM DYNAMICS, FIELD CALCULATIONS, AND ION OPTICS

*REFER ALSO TO CITATION(S) 5831*

## AUXILIARIES AND COMPONENTS

*REFER ALSO TO CITATION(S) 5531, 5533, 6072*

**5597** (LA-UR—76-1666) **Reliability and operating experience of the LAMPF 805-MHz rf system.** Tallerico, P.J. (Los Alamos Scientific Lab., N.Mex. (USA)). 1976. Contract W-7405-Eng-36. 6p. (CONF-760924—1). Dep. NTIS $3.50.

From 6. European microwave conference; Rome, Italy (14 Sep 1976).

Over 850,000 hours have been accumulated on the klystrons and modulators that constitute the LAMPF 805-MHz rf system. The 1-1/4 MW klystrons, the floating-deck modulators, and the modulator triodes are described. The operating data are summarized, and the fault and failure modes are tabulated for the three major components of the system. The high-voltage processing and other maintenance required to keep this 86-kV system operating reliably are described. The tube failure rates, tube fault rates, and modulator fault rates are presented. The mean time to failures is greater than 56,500 h for the klystrons and greater than 40,600 h for the modulator triodes. The steps taken to produce such good reliability are discussed.

**5598** **Shielding calculations for a 200-MeV proton accelerator and comparisons with experimental data.** Alsmiller, R.G. Jr.; Santoro, R.T.; Barish, J. (Oak Ridge National Lab., Tenn. (USA)). *Part. Accel.*; 7: No. 1, 1-7(1975).

Calculated results, obtained using a combination of Monte Carlo and discrete ordinates methods, are presented and compared with experimental activation and dose-equivalent data for 200-MeV protons incident on a thick water shield. The calculational geometry is only very approximately that used experimentally, but reasonable agreement between the calculated and experimental data was obtained. Calculated results of the neutron spectra produced in various angular intervals by 200-MeV protons in thin and thick aluminium targets and the dose equivalents as a function of radius in a concrete shield when these spectra are isotropically incident at the center of the shield are also presented.

**5599** **Simply focused neutrino beams.** Benvenuti, A.; Cline, D.; Ford, W.T.; Imlay, R.; Ling, T.Y.; Mann, A.K.; Orr, R.; Reeder, D.D.; Rubbia, C.; Stefanski, R. (Harvard Univ., Cambridge, Mass. (USA). Dept. of Physics; Pennsylvania Univ., Philadelphia (USA). Dept. of Physics; Wisconsin Univ., Madison (USA). Dept. of Physics; Fermi National Accelerator Lab., Batavia, Ill. (USA)). pp 397-403 of In La physique du neutrino a haute energie. Paris; Centre National de la Recherche Scientifique (1975).

From International colloquium on high energy neutrino physics; Paris, France (18 Mar 1975).

A neutrino beam specifically designed for an easy calculation of the energy dependence of the neutrino spectrum on the hadron spectrum is described. The beam is focused by quadrupoles with a limited target angle (<2mrad), so that only forward yields are important to determine neutrino spectra. The design includes a facility for measuring the forward production of pions and kaons.

**5600** **Solenoid-lens effects in beam-transport equations.** Cooper, R.K. (California Univ., Livermore (USA). Lawrence Livermore Lab.). *Part. Accel.*; 7: No. 1, 41-47(1975).

Beam-transport equations governing the transport of low-energy charged-particle beams are modified to include the effects of magnetic (solenoid) lenses. The rms beam-transport equations are modified for the case in which the beam entering the magnetic lens has the same particle distribution in both x and y (the transverse coordinates) and the beam is symmetric in both coordinate directions. An alternative treatment is presented for the case where space-charge forces can be neglected.

**5601** **Laser induced fusion and x-ray laser studies.** Jacobs, S.F.; Scully, M.O.; Sargent, M. III; Cantrell, C.D. III. Reading, MA; Addison-Wesley Publishing Co. (1976). 683p. $27.50.

A separate abstract was prepared for each of the 12 lectures presented at the 1975 Summer School. (RCK)

### EXPERIMENTAL FACILITIES AND EQUIPMENT

**5602** (LA-tr—76-18) **Windowless gas target by the gas dynamic focusing of a supersonic neutral gas flow.** Tietsch, W.; Bethge, K.; Feist, H.; Schopper, E. (Gesellschaft fuer Schwerionenforschung m.b.H., Darmstadt (Germany, F.R.)). Nov 1975. Translation of GSI-P—3-75. 37p. Dep. NTIS $4.00.

A description is given of a target system which permits high target densities in a well-defined cylinder with a diameter of one to two millimeters with a simultaneous reduction in the secondary gas yield. The gas expands in a conical space in which a static pressure is present which is exceeded by several magnitudes by the inlet pressure of the nozzle. The supersonic beam exits this space required for the formation of the focused flow through an opening in the cone tip and is removed by pumping. The compression node can be positioned directly in the reaction plane by varying the

distance of the Laval nozzle opening to the opening of the hollow cone. For the operation of a windowless gas target, a three-step differential pump system was installed concentrically around the gas beam. The most important characteristics of the system are briefly summarized.

**5603 Versatile multipole correction magnet of rectangular aperture.** Peterson, R.J.; Kraushaar, J.J.; Ristinen, R.A. (Colorado Univ., Boulder (USA). Nuclear Physics Lab.); Thiessen, H.A. (Los Alamos Scientific Lab., N.Mex. (USA)); Rickey, M.E. (Indiana Univ., Bloomington (USA). Dept. of Physics). *Nucl. Instrum. Methods;* **129**: No. 1, 47-51(1 Nov 1975).

A rectangular aperture multipole magnet in which multipole components are independently variable has been designed and constructed. This magnet is intended for use as an adjustable trim element in a precision spectrometer system. No organic materials are used in the assembly, and the magnet is suitable for use in a high radiation environment.

**5604 Production of a high density hydrogen gas jet.** Gross, D.A.; Melissinos, A. (Rochester Univ., N.Y. (USA). Dept. of Physics and Astronomy). *Nucl. Instrum. Methods;* **130**: No. 1, 1-13(1 Dec 1975).

Pulsed supersonic jets of $H_2$ and He have been produced with densities of the order of $10^{-7}$ g/cm$^3$, for durations of 25-200 ms. The densities were measured with a constant temperature anemometer that was constantly self-calibrated in a static pressure mode by the determination of accomadation coefficients of the gases used. Such supersonic jets are to be used as internal targets in high energy experiments.

## STORAGE RINGS

**5605 Targets for storage rings.** Baturin, P.I.; Popov, S.G.; Toporkov, D.K. *Sov. Phys. - Tech. Phys. (Engl. Transl.);* **21**: No. 3, 371-373(Mar 1976).

A discussion is given of the use of ultra thin gaseous targets in electron storage rings. It is proposed that the best method of producing there targets is through the use of a high intensity molecular beam. (AIP)

# INSTRUMENTATION

## RADIATION INSTRUMENTATION

*REFER ALSO TO CITATION(S) 4543, 5669*

### GENERAL DETECTORS AND MONITORS

*REFER ALSO TO CITATION(S) 4545, 4996, 5612, 5630, 5643*

**5606** (RFP—2525) **High-purity germanium detection system for the in vivo measurement of americium and plutonium.** Tyree, W.H.; Falk, R.B.; Wood, C.B.; Liskey, R.W. (Atomics International Div., Golden, Colo. (USA)). 8 Sep 1976. Contract E(29-2)-3533. 12p. Dep. NTIS $4.00.

A high-purity germanium (HPGe) array, photon-counting system has been developed for the Rocky Flats Plant Body-Counter Medical Facility. The newly improved system provides exceptional resolutions of low-energy X-ray and gamma-ray spectra associated with the in vivo deposition of plutonium and americium. Described are the operational parameters of the system and some qualitative results illustrating detector performance for the photon emissions produced from the decay of plutonium and americium between energy ranges from 10 to 100 kiloelectron volts. Since large amounts of data are easily generated with the system, data storage, analysis, and computer software developments continue to be an essential ingredient for processing spectral data obtained from the detectors. Absence of quantitative data is intentional. The primary concern of the study was to evaluate the effects of the various physical and electronic operational parameters before adding those related entirely to a human subject.

**5607** (AEC-tr—7533/9, pp 29-34) **Electronic system incorporating a monolithic comparator and logic integrated circuits for selection of alpha and beta particles.** Kazubek, M.; Modzelewski, A. (Warsaw Tech. Univ.). Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

A pulse shape discriminator has been described for resolving pulses evoked by alpha and beta particles, based on the zero crossing method. A fast monolithic comparator is used as the zero crossing detector. TTL integrated circuits are employed for logic selection of pulses. Representative results are presented.

**5608 Calibrated glass standards for fission track use.** Carpenter, B.S.; Reimer, G.M. (NBS, Washington, DC). *Natl. Bur. Stand. (U.S.), Spec. Publ.;* No. 260-49, (Nov 1974).

Four glasses of different uranium concentrations were prepared and certified by the National Bureau of Standards as standards for use as neutron monitors to aid fission track studies. These Standard Reference Materials (SRM) and their uranium concentrations are: SRM 941 (461 ppm), SRM 962 (37.4 ppm), SRM 963(0.823 ppm), and SRM 964 (0.0721 ppm). These glass wafers were irradiated in the National Bureau of Standards Reactor and the neutron flux was monitored using copper and gold foils. Data are shown in tabular and graphical form.

**5609 Background reduction and noise discrimination in the proportional counting of tritium using pulse-shape analysis.** Hochel, R.C.; Hayes, D.W. (Du Pont de Nemours (E.I.) and Co., Aiken, S.C. (USA). Savannah River Lab.). *Nucl. Instrum. Methods;* **130**: No. 1, 183-188(1 Dec 1975).

A pulse-shape analysis (PSA) unit of commercial design has been incorporated into a proportional counting system to determine the effectiveness of pulse-shape discrimination in increasing the sensitivity of tritium counting. It was found that a quantitative determination of tritium could be obtained directly from the PSA time spectrum eliminating the need for beta-ray energy selection used in the pulse-shape discrimination (PSD) technique. The performance of the proportional counting system was tested using the PSA unit and anticoincidence shielding, both singly and combined, under several types of background. A background reduction factor of 169 was obtained from the combined PSA-anticoincidence system with only a 2% loss in tritium counting efficiency. The PSA method was also found to offer significant reductions in noise background.

**5610 Proton and hydrogen atom detection efficiency of resistance strip magnetic electron multiplier particle-counting system.** Wehrenberg, P.J.; Clark, K.C. (Physics Department and Geophysics Program, University of Washington, Seattle, Washington 98195). *Rev. Sci. Instrum.;* **47**: No. 10, 1255-1257(Oct 1976).

The absolute detection efficiency for protons and for hydrogen atoms in the energy range 5—60 keV is determined for a resistance strip magnetic electron multiplier particle-counting system. Significant history-dependent gain variations are discussed. The detector system is suitable for use in coincidence experiments requiring particle-counting rates to 1.0 MHz and timing accuracies of 3.0 nsec. (AIP)

### RADIATION DOSEMETERS

**5611 Computational extension of the dynamic range of TL and TSEE readers.** Jun, J.S.; Talmage, J.E.; Becker, K. (Oak Ridge National Lab., Tenn. (USA)). *Nucl. Instrum. Methods;* **129**: No. 1, 247-250(1 Nov 1975).

In situations in which the measurability of thermoluminescence or exoelectron emission glow curves is limited by the characteristics of the readout instrument (e.g., saturation in proportional or gas counters), the peak can be 'reconstructed' as if it were recorded in full by proper evaluation of the reliably recorded low-T and high-T segments of the peak. The results of two different methods have been compared, assuming (a) a Gaussian shape or (b) linear scaling of the glow curves, with a parabolic shape at the low-T and a linear shape at the high-T side. The procedures are simplified by using the combination of a digitizer and a programmable calculator. The usable dynamic range of various radiation dosimeters can thus be extended by about two orders of magnitude.

**5612 Exploration study of the use of TSEE dosimeters in radon monitoring.** Gammage, R.B.; Kerr, G.D.; Huskey, L. (Oak Ridge National Lab., Tenn. (USA)). *Health Phys.;* **30**: No. 1, 145-148(Jan 1976).

Brief note.

**5613 International intercomparison of environmental dosimeters.** Gesell, T.F. (Texas Univ., Houston (USA)); Burke, G.D.P.; Becker, K. *Health Phys.;* **30**: No. 1, 125-133(Jan 1976).

Based on the results of a pilot study at ORNL in 1973, a more comprehensive international intercomparison of integrating dosimeters for the assessment of external penetrating environmental radiation fields was carried out. Forty-one laboratories from 11 countries participated in this study. A total of 56 sets of six detectors each were used. Evaluation of the dosimeters provides information on the calibration precision, the accuracy of field measurement, and transit exposure.

## NUCLEAR SPECTROSCOPIC INSTRUMENTATION

*REFER ALSO TO CITATION(S) 4541, 5644, 6061*

**5614** (ANCR—1179) **π root 2 iron-free magnetic electron spectrometer.** Helmer, R.G. (Idaho National Engineering Lab., Idaho Falls (USA)). Aug 1976. Contract E(10-1)-1375. 65p. Dep. NTIS $4.50.

The Radioactivity and Decay Schemes group at the Idaho National Engineering Laboratory has constructed and operated a $\pi\sqrt{2}$, iron-free, magnetic electron spectrometer. This instrument is of the "Chalk River" design with three pairs of circular coils to produce the magnetic field. The optic circle radius is 35 cm. The diameters of the coils and their axial separations were chosen to produce the desired magnetic field. This spectrometer is capable of measuring electron and positron spectra up to approximately 3.3 MeV with a resolution (i.e., relative FWHM) variable from 1 to 0.01 percent. A PDP-8/E computer is used to operate and monitor the spectrometer. It is programmed to automatically set the current in the coils, monitor the current and control the counting intervals. The spectrometer is housed in a building constructed of nonmagnetic materials and is situated to minimize the magnetic interference from vehicular movements. The spectrometer has been used to measure the continuous electron and positron spectra from several isotopes as well as several conversion electron spectra.

**5615** (CH—3193-3) **High-purity germanium for gamma detectors. Annual report No. 7.** Hall, R.N.; Berninger, W.H.; Soltys, T.J. (General Electric Co., Schenectady, N.Y. (USA)). May 1975. Contract E(11-1)-3193. 10p. (SRD—75-068). Dep. NTIS $3.50.

Improved methods for the fabrication of large volume coaxial detectors made from high purity germanium are described. Methods for making electrical contacts, mechanical processing, and contract support activities are discussed. (WHK)

**5616** (EGG—1183-2342) **Advances in mercuric iodide single crystal nuclear detectors.** Randtke, P.T.; Ortale, C.; Whited, R.C.; van den Berg, L. (EG and G, Inc., Santa Barbara, Calif. (USA)). 1976. Contract E(29-1)-1183. 4p. (CONF-760539—6). Dep. NTIS $3.50.

From ERDA symposium on x- and gamma-ray sources and applications; Ann Arbor, Michigan, United States of America (USA) (19 May 1976).

The preparation of crystalline detector material of high perfection, the methods used for its characterization, and the fabrication of individual detectors are described. Major progress has been made in the uniformity of large-area (1 cm x 1 cm x 0.5 mm) detectors manufactured from crystals having a low dislocation density. An array of nine individual matched detectors has been built and evaluated.

**5617** (ORNL-tr—4213) **Sensitivity of Ilford $Q_1$ plates.** Burlefinger, E.; Ewald, H. Translated by R.G. Mansfield from *Z. Naturforsch., a;* **16a**: 430-431(1961). 4p. Dep. NTIS $3.50.

The sensitivity of Ilford $Q_1$ plates used in mass spectroscopy for ions with an energy of about 17.5 keV was studied as a function of the mass of the ions under otherwise equal conditions. The evaluation showed proportionality between ionic and grain density for each ion mass. The relative sensitivity is tabulated for various ions. (WHK)

**5618** (AEC-tr—7533/9, pp 41-46) **New automatic gamma spectrometer for measuring angular correlation of annihilation quanta, constructed at the Institute for Experimental Physics, University of Wroclaw.** Rozenfeld, B.; Baranowski, A.; Jerie, K. (Bierut Univ., Wroclaw). Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

A new gamma spectrometer for measuring angular correlation of annihilation quanta has been constructed at the Institute for Experimental Physics, University of Wroclaw. The time and the angular resolutions of the spectrometer are better than $5 \times 10^{-9}$ sec and 0.8 mrad, respectively, the latter being refinable down to 0.25 mrad. Such resolution parameters are characteristic of a world's good class of this type of spectrometers.

**5619** **High resolution spectrometry for relativistic heavy ions.** Gabor, G.; Schimmerling, W.; Greiner, D.; Bieser, F.; Lindstrom, P. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). *Nucl. Instrum. Methods;* **130**: No. 1, 65-71(1 Dec 1975).

Several techniques are discussed for velocity and energy spectrometry of relativistic heavy ions with good resolution. A foil telescope with chevron channel plate detectors is described. A test of this telescope was performed using 2.1 GeV/A $C^{6+}$ ions, and a time-of-flight resolution of 160 ps was measured. Qualitative information on the effect of foil thickness was also obtained.

**5620** **Electron energy spectrometer of retarding field type.** Hori, H.; Maeda, N.; Kobayashi, N.; Sakisaka, M. (Kyoto Univ. (Japan). Faculty of Engineering). *Nucl. Instrum. Methods;* **130**: No. 1, 135-141(1 Dec 1975).

An electron energy spectrometer of straight and two-stage retarding field type is presented, where the electric potential on the axis is chosen symmetric as PHI(z) proportional to exp (αmod(z)/L) for -L<=z<=L (α: positive eigenvalue) in each stage. According to the solution of the trajectory, the spectrometer is so designed as to filter electrons with double focusing. The energy resolution of a compact spectrometer is 2-3 eV in the range of 50-2000 eV and that of a longer one is less than 1 eV. The spectrometers have worked satisfactorily in measuring Auger electrons emitted from ion-atom and electron-atom collisions.

## HIGH ENERGY PHYSICS INSTRUMENTATION

**5621** **Cherenkov threshold-differential spectrometer.** Dibianca, F.A.; Dunaitsev, A.F.; Kolganov, V.Z.; Mukhin, A.I.; Nezrick, F.A.; Sittler, F. (Fermi National Accelerator Lab., Batavia, Ill. (USA)). *Nucl. Instrum. Methods;* **129**: No. 1, 59-63(1 Nov 1975).

A new type of threshold-differential Cherenkov spectrometer has been developed to measure the flux and momentum distribution of high intensity charged particle beams in an intense charged particle background. The spectrometer is intended primarily for use in monitoring and measuring the properties of wide-band neutrino beams by measuring the associated decay muon spectrum. The spectrometer has been tested in a beam of 300 GeV/c protons and found to have 8% momentum resolution, 2 mrad angular resolution and 0.1% efficiency.

**5622** **400 GeV shower counter.** Knauer, J.P.; Yount, D.E. (Hawaii Univ., Honolulu (USA). Dept. of Physics and Astronomy). *Nucl. Instrum. Methods;* **129**: No. 1, 91-94(1 Nov 1975).

Specifications and test data are given for a lead-scintillator electromagnetic shower counter used to detect beam photons at Fermi National Accelerator Laboratory. The response is independent of beam position to +- 1.4% rms over a 25 cmx25 cm area. Shower penetration losses reach 4.1% at 250 GeV but are easily calculable. The resolution is limited almost entirely by fluctuations in the number of shower tracks sampled. The full-width-at-half-maximum is approximately 43% Esup(1/2), where E is the incident energy in GeV.

**5623** **Calibration of a sampling total absorption detector designed for neutrino experiments.** Barish, B.C.; Bartlett, J.F.; Bodek, A.; Brown, K.W.; Buchholz, D.; Jacquet, F.; Merritt, F.S.; Sciulli, F.J.; Stutte, L.; Suter, H. (California Inst. of Tech., Pasadena (USA)). *Nucl. Instrum. Methods;* **130**: No. 1, 49-60(1 Dec 1975).

A sampling total absorption detector was calibrated at Fermilab for energies in the range 5-250 GeV. The calorimeter consisted of a sandwich of scintillator slabs and 4 inch thick steel plates. Energy resolutions (rms) of +- 33%, +- 16%, and +- 9% were acheived for the energies of 10, 50 and 150 GeV, respectively.

**5624** **Observation of transition radiation from pions at 100-250 GeV.** Yuan, L.C.L.; Alley, P.W.; Dell, G.F.; Keller, R.; Uto, H. (Brookhaven National Lab., Upton, N.Y. (USA)). *Nucl. Instrum. Methods;* **130**: No. 1, 41-43(1 Dec 1975).

The observation of transition radiation from pions at 100-250 GeV using a transition radiation detector (TRD) is reported on. The detector consisted of multiwire proportional chambers and foil radiators. The observed spectra and efficiences for separating pions from protons in this energy region are presented.

**5625** **Transition radiation from electrons at 50 GeV.** Yuan, L.C.L.; Alley, P.W.; Dell, G.F.; Keller, R.; Uto, H. (Brookhaven National Lab., Upton, N.Y. (USA)). *Nucl. Instrum. Methods;* **130**: No. 1, 45-47(1 Dec 1975).

An investigation to separate electrons from pions at 50 GeV using a transition radiation detector (TRD) consisting of multiwire proportional chambers and stacks of mylar foil radiators is presented. The pulse height distribution from such a detector shows two peaks which correspond to pions and electrons respectively. Ethafoam and styrofoam were also used as radiators. The observed energy spectra and application of the detector are discussed.

## RADIOMETRIC INSTRUMENTS

*REFER ALSO TO CITATION(S) 5629, 5635, 5639, 5642, 5644*

## RADIATION EFFECTS ON INSTRUMENT COMPONENTS, INSTRUMENTS, OR ELECTRONIC SYSTEMS

*REFER ALSO TO CITATION(S) 4670*

**5626** (AD-A—012729) **EMP shielding properties of conduit systems and related hardware. Final report.** Leverenz, D.J.; Nielsen, P.H.; McCormack, R.G. (Army Construction Engineering Research Lab., Champaign, Ill. (USA)). Jun 1975. 102p. (CERL-TR-C—19). NTIS $5.25.

This report presents the results obtained by CERL over the past 3 years under its investigation of the shielding properties on conduit systems, conduit-related hardware, and the effects of improper field assembly on the shielding of conduit systems. The measurements were made by injecting EMP-type current pulses onto test conduits and measuring the signal picked up on a sense wire inside the conduit. Results are presented for the measurement of both diffusion and leakage signals. The diffusion signal provides a base line for the conduit shielding since it is the optimum shielding obtainable for a given size and material of conduit. The leakage signals represent a degradation of the conduit shielding due to the insertion of conduit hardware required to assemble the conduit runs, or to the improper assembly of the conduit system. Included in the leakage study were various hardware items including couplings, unions, conduits of various sizes, flexible conduit, condulets, lock nuts, threaded hubs, and a variety of condulet gaskets. In addition, the effects of thread corrosion, use of different conductive compounds, various methods of compound application, welding near couplings, and the inadequate tightening of threaded joints were evaluated. The greatest single factor in the degradation of the shielding effectiveness of conduit assemblies was the inadequate tightening of conduit joints. (GRA)

**5627** (AD-A—013016) **Radiation-hardened CMOS/SOS standard cell circuits. Quarterly report No. 1, 3 Feb—3 May 1975.** Pryor, R.L.; Feller, A. (RCA Advanced Technology Labs., Camden, N.J. (USA)). Jun 1975. Contract N00014-75-C-0709. 39p. (ATL-CR—75-09). NTIS $3.75.

The basic design procedure and the basic topology for a family of CMOS/SOS radiation-hardened standard cells were defined. The basic design procedure consisted of two principal steps. One involved the layout of the cells. To minimize the effect of radiation when back-biased, all substrates of stacked devices were connected to each other and to supply or ground. In the case of P-type stacked devices, both ends of the channel substrates were connected to V/sub DD/. The second step involved extensive detail design and simulation of the various circuit types to determine the device sizes. The radiation-induced upset levels of various circuit alternatives for the complex cells were analyzed. From this analysis came a set of guidelines for circuit design in terms of circuit complexity, use of transmission gates, etc. The initial design or layout for all of the adder cells was implemented. Several cells, representing various cell groups, were examined and analyzed in considerable detail to permit verification of selected device sizes. The logic configuration of the test chip was defined. (GRA)

**5628** **From radiation hardening to ionizing radiation of quartz resonators.** King, J.C. (Sandia Labs., Albuquerque, N.Mex. (USA)). pp 181-208 of In Evaluation de l'action de l'environnement spatial sur les materiaux. Toulouse; Centre National d'Etudes Spatiales (Jun 1974).

From International conference on evaluation of space environment on materials; Toulouse, France (17 Jun 1974).

Accumulated performance data on the stability of quartz resonators in earth orbiting satellites, as well as similar information gained from deep space probes, underscore the importance of reducing the effects of ionizing radiation on these critical system components. The phenomenological response of precision AT-cut resonator to both steady state and pulse radiation is briefly reviewed. The resultant frequency offset and change in resonator Q have been interpreted in terms of radiation-induced changes in certain point defects in the quartz crystal structure. These defects involve interstitial monovalent cations which can be removed by solid diffusion along the optic axis at elevated temperatures in the presence of an electric field. High Q precision resonators fabricated from such swept quartz exhibit an extraordinary intensitivity to ionizing radiation relative to untreated quartz.

## MISCELLANEOUS INSTRUMENTS

*REFER ALSO TO CITATION(S) 4411, 4490, 5022, 5505*

**5629** (N—75-24593) **Data user's notes of the radio astronomy experiment aboard the OGO-V spacecraft.** Haddock, F.T.; Breckenridge, S.L. (Michigan Univ., Ann Arbor (USA)). 20 Apr 1970. Contract NAS5-9099. 46p. (NASA-CR—143696; UM/RAO—70-3). NTIS $3.75.

General information concerning the low-frequency radiometer, instrument package launching and operation, and scientific objectives of the flight are provided. Calibration curves and correction factors, with general and detailed information on the preflight calibration procedure are included. The data acquisition methods and the format of the data reduction, both on 35 mm film and on incremental computer plots, are described. (GRA)

**5630** (ORNL—4990) **Instrumentation and Controls Division annual progress report for period ending September 1, 1973.** Sadowski, G.S. (comp.). (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 118p. Dep. NTIS $5.50.

Research progress is described under the following topics: (1) pulse counting and analysis; (2) support for the thermonuclear division ORMAK project; (3) miscellaneous electronics development; (4) detectors of ionizing particles and radiation; (5) radiation monitoring; (6) support for the Oak Ridge Electron Linear Accelerator; (7) automatic control and data acquisition; (8) process instrumentation and control; (9) reactor instrumentation and controls; (10) instrumentation for reactor division experiments and test loops; (11) maintenance and service; and (12) ecological science studies. (WHK)

**5631** (UCID—17165) **Evaluation of the Kulite semiconductor strain gage, model M(6) EP-120-500W, spotwelded to P-110 pipe material.** Roach, D.R.; Freynik, H.S. Jr. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 13 Jul 1976. Contract W-7405-eng-48. 21p. Dep. NTIS $4.00.

The Kulite dual-element, semiconductor strain gage, weldable model M(6)-EP-120-500W, was evaluated in laboratory tests under simulated Nevada Test Site conditions. Two gages were installed on P-110 line-of-sight pipe material. Tension was applied to the test samples to 50 percent of yield (about 2000 microstrain). Immediately following, compression was applied to 100 percent of yield (about 6000 microstrain). The Kulite gages were powered by a dual constant current signal conditioner. Measurements obtained with metal foil strain gages served as reference standards for the Kulite strain gage measurements. The output voltages of the Kulite gages were relatively linear from zero to +2000 microstrain and in the subsequent compression to -2500 microstrain. Below -2500 microstrain, the output voltages from the Kulite gages became decidedly nonlinear and also differed significantly from each other. We feel that the gage spotwelds were failing at strains below -2500 microstrain and consequently that data obtained below this level are not reliable enough to calculate pipe forces. The stated gage factor (Kulite factory) of 220 is about 33 percent higher in tension than the measured gage factor and about 15 percent higher in compression. Adhesive-bonded, metal foil strain gages are recommended for reliable pipe force measurements on future Nevada Test Site events. Metal foil gages consistently are linear and reliably measure strains in excess of +-10,000 microstrain.

**5632** (AEC-tr—7533/9, pp 8-13) **Time-to-digit converter.** Tlaczala, W.; Basiladze, S.G.; Smirnov, V.A. (Warsaw Tech. Univ.). Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

A time-to-digit converter operated on the START-STOP principle has been devised. The time interval measured is converted into the number of periods of a start oscillator and a modified vernier method is used to interpolate time fragments between the latest counted pulse of the start oscillator and the end of the time interval. The minimum channel width is 110 psec; the number of channels, $2^{16}$; overall nonlinearity, 1 percent. The converter has been built in the CAMAC standard.

**5633** (AEC-tr—7533/9, pp 14-18) **Digital-controlled nanosecond delay module in the CAMAC standard.** Tlaczala, W.; Basiladze, S.G. (Warsaw Tech. Univ.). Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

A computer-controlled double delay module for the nanosecond interval has been described. The dynamic delay range and the minimum delay increment are 1 to 63 nsec and 1 nsec, respectively. The temperature stability and supply-voltage drift of delay are 0.1 per 1 degree centigrade and 1 nsec per 1 volt, respectively. The delay accuracy, +-2 percent; the maximum operation rate, 80 MHz. The module has been developed as a CAMAC standard. Provision has been made for manual control to be executed from the front panel.

## WELL LOGGING INSTRUMENTATION

*REFER ALSO TO CITATION(S) 4452, 4541*

**5634 Handbook of well log analysis for oil and gas formation evaluation.** Pirson, S.J. Englewood Cliffs, NJ; Prentice-Hall, Inc. (1963). 337p. $22.50.

A handbook on the interpretation of well log data for evaluating the productive capacities and the reserves of prospective, as well as existing, oil and gas fields is presented. Chapter titles include clastic reservoir rocks; carbonate reservoir rocks; petrophysics; reservoir fluid properties and formation productivity evaluation; the well log interpretation problem; spontaneous polarization (SP) curve; normal curves; lateral curves; limestone curve; wall-resistivity logs and microcaliper log; qualitative interpretation of conventional electric logs; conductivity focused-current logs; micro-focused logs; inductively focused-current logs; gamma-ray log; gamma-gamma log; neutron logs; nuclear magnetic log; elastic wave propagation log; temperature log; diagnostic and semi-quantitative interpretation of common log combinations; comprehensive quantitative well log interpretation in granular clean water-wet rocks; comprehensive quantitative well log interpretation in granular shaly water-wet rocks; comprehensive quantitative well log interpretation in granular oil-wet rocks; and comprehensive quantitative well log interpretation in multiple-porosity type reservoir rocks. (WHK)

**5635 Dual-spaced epithermal neutron detector porosity logging with AcBe source.** Scott, H.D. (to Texaco, Inc.). US Patent 3,906,224. 16 Sep 1975. Filed date 12 Oct 1973. vp.

A relatively high intensity ($10^8$ neutrons/sec) actinium-beryllium neutron source irradiates earth formations surrounding a well borehole. Two cadmium-wrapped $^3He$ detectors spaced at about 46 and 76 cm from the neutron source measure the epithermal neutrons deflected back to the borehole. The ratio of the counting rates in the two detectors is related to the earth formation porosity.

**5636 Methods and apparatus for logging flow characteristics of a well.** Mullins, L.D. (to Mobil Oil Corp.). US Patent 3,908,454. 30 Sep 1975. Filed date 9 Jan 1974. vp.

Method An ultrasonic transducer measures the liquid and particulate flow near a formation in a well. The resonance of a piezoelectric disc around 100 kHz is excited by the ultrasonic components generated by fluid flow against the logging tool housing and a higher resonance near 700 kHz detects the particles striking the housing. The output signals are frequency-modulated and sent to the surface of the ground.

**5637 Apparatus and method for indicating at the surface the measurement of a downhole condition.** Jeter, J.D. US Patent 3,908,453. 30 Sep 1975. Filed date 24 Oct 1973. vp.

Apparatus Downhole conditions, such as the inclination and direction of a well, or the temperature adjacent the bottom of the well, are measured while drilling. The delay, after a sensor measures a downhole parameter and a pressure pulse is generated and transmitted to the surface, is proportional to the downhole parameter. The delay can be measured directly, in revolutions of the pipe string, or in the volume of fluid pumped through the drill string.

**5638 Methods and apparatus for acoustic logging through casing.** Lavigne, J.C. (to Schlumberger Technology Corp.). US Patent 3,909,775. 30 Sep 1975. Filed date 26 Oct 1973. vp.

An acoustic logging tool transmits an impulse with a center frequency around 10 kHz to a receiver at a minimum distance of about 5 ft. This arrangement permits detection of acoustic energy traveling through formations surrounding the borehole in preference to acoustic impulses traveling in the casing. Greater signal amplitude is obtained than with higher frequencies previously used. The large separation of the receiver from the source gives higher resolution for fast formations and greater amplitude discrimination of received signals with slow formations because of the increased damping of the casing wave.

**5639 Neutron lifetime well-logging methods and apparatus.** Paap, H.J. (to Texaco, Inc.). US Patent 3,914,603. 21 Oct 1975. Filed date 17 Dec 1973. vp.

A neutron source, preferably of the deuterium-tritium accelerator type, is intensity modulated at about 400 Hz in a well-logging tool. A spaced gamma ray detector measures the thermal neutron population resulting from the slowing down of the fast neutrons in the borehole and the surrounding formation, and a spaced neutron detector measures primarily the thermal neutron population attributable to the borehole. At the earth's surface the phase angle of the formation component is found by subtracting the phase angle of the borehole component from the phase angle of the composite borehole and formation components. The thermal neutron capture cross-section or decay time is calculated from the formation component value and recorded.

**5640 Well-logging apparatus including a releasable extendible spring member having a wellbore wall engaging contact.** Brooks, R.A. (to Continental Oil Co.). US Patent 3,914,686. 21 Oct 1975. Filed date 25 Mar 1974. vp.

Well-LThe voltage differential between a wellbore wall and a reference potential is measured with a logging tool that has an extendible arcuate spring. The movable bottom end of the spring is released by melting with electric current a Nichrome wire attached to it. A scraper cleans the wall as the tool is raised, and a sharpened platinum alloy electrode makes a good contact with the wall of the hole.

**5641 Well-logging system and method using an armored coaxial cable and compensation circuit.** Paap, H.J. (to Texaco Inc.). US Patent 3,916,685. 4 Nov 1975. Filed date 27 Oct 1971. vp.

The armored coaxial cable of a well-logging system has an inner conductor for sending electric pulses uphole and supplying high voltage downhole, a copper coaxial shield for providing a return path for the pulses and carrying low voltage downhole, and an outer armor serving as a common ground. A circuit at the surface compensates for the deterioration of the signal pulses during their transmission up the cable in accordance with the deterioration of monitored reference pulses that are generated in the logging instrument.

**5642 Pulsed neutron combination well-logging system.** Peelman, H.E. (to Texaco Inc.). US Patent 3,928,762. 23 Dec 1975. Filed date 6 May 1974. vp.

The hydrogen-to-oxygen ratio, chlorine content, and thermal neutron lifetime information are simultaneously determined in the vicinity of a cased well bore with a pulsed neutron logging system. A downhole pulsed neutron source repetitively irradiates the borehole environs with approximately one msec 14 MeV neutron bursts. Gamma rays attributable to the capture of neutrons by elemental hydrogen, chlorine, and oxygen near the borehole are determined by inputing three time gates to a multichannel pulse height analyzer.

**5643 Nonfluid-filled borehole logging apparatus.** Sherman, H. (to Schlumberger Technology Corp.). US Patent 3,932,747. 13 Jan 1976. Filed date 23 May 1974. vp.

An elongated sleeve made of a hydrogenous material, such as a high-density polyethylene, is attached to the portion of the sonde which has a radiation detector when performing radioactive logging in a nonfluid-filled borehole. The sonde is located in the open end of the crescent-shaped horizontal cross-section of the sleeve.

**5644 Dual-function logging tool and method.** Kampfer, J.G. (to Halliburton Co.). US Patent 3,935,556. 27 Jan 1976. Filed date 21 May 1974. vp.

A well-logging tool detects naturally occurring gamma rays in addition to the radiation produced by the bombardment of nearby formations with a radioactive source. The frequency of the usual amplitude reference pulses, generated to calibrate the system, is a sum of the output frequency of a downhole oscillator (approximately equal to 100 Hz) and the frequency of the naturally occurring gamma radiation.

## EXPLOSIONS AND EXPLOSIVES

*REFER ALSO TO CITATION(S) 5779*

### CHEMICAL

*REFER ALSO TO CITATION(S) 4548*

**5645 Mesh-initiated large area detonators.** Butler, R.I.; Cowan, M.; Duggin, B.W.; Mathews, F.H. (Sandia Laboratories, Albuquerque, New Mexico 87115). *Rev. Sci. Instrum.*; 47: No. 10, 1261-1263(Oct 1976).

Inexpensive large area detonators are described which utilize a mesh of etched copper brigewires to detonate PETN. Breakout simultaneity within 100 nsec is achieved on the surface of a PBX-9407 booster at discrete initiation points originating from the individual bridgewires. Initiation point densities as high as 3.1 x $10^5$ $m^{-2}$ are achieved by printed circuit manufacturing techniques.

Electrical requirements are established from threshold burst current experiments. Two initiators are described; a general purpose 200-mm diam detonator, employing 750 or 10 000 bridgewires (depending on the mesh pattern used), and a 150 x 600 mm detonator employing 2300 that was developed for a fast explosive generator. These detonators achieve simultaneous detonation of large surface areas at lower cost and with much less explosive than conventional lens systems. They can also be applied to singly curved surfaces. (AIP)

## NUCLEAR

*REFER ALSO TO CITATION(S) 5631*

**5646** (UCID—17144) **Spall study in one dimension.** Glenn, H.D. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 6 Apr 1976. Contract W-7405-Eng-48. 46p. Dep. NTIS $4.00.

A SOC one-dimensional calculation of an underground nuclear test is presented to exemplify the shock propagation and spall phenomenology commonly predicted. Then to examine the effects of spherical divergence on spall, a series of SOC calculations, at different radii of curvature, are conducted and prediction of depth and velocity for the first spall zone are compared with predictions from simple analytic theory. The excellent agreement in this comparison verifies that the SOC code accurately represents the physics of spalling. This study also indicates that the total spall depth is independent of divergence because of the compensating effect that subsequent convergence has on the reflected wave. The latter result implies that the total depth of spall calculated for each underground nuclear tests must be critically examined and evaluated. Finally, SOC calculations for nuclear detonations in tuff and granite are performed to demonstrate the significant effect that variations in material response under shock loading have on shock propagation and spall.

**5647** (WASH—1526(Suppl.)) **Underground Nuclear Testing Program, Nevada Test Site.** (Energy Research and Development Administration, Washington, D.C. (USA)). Sep 1975. 86p. Dep. NTIS $5.00.

The Energy Research and Development Administration (ERDA) continues to conduct an underground nuclear testing program which includes tests for nuclear weapons development and other tests for development of nuclear explosives and methods for their application for peaceful uses. ERDA also continues to provide nuclear explosive and test site support for nuclear effects tests sponsored by the Department of Defense. This Supplement extends the Environmental Statement (WASH-1526) to cover all underground nuclear tests and preparations for tests of one megaton (1 MT) or less at the Nevada Test Site (NTS) during Fiscal Year 1976. The test activities covered include numerous continuing programs, both nuclear and non-nuclear, which can best be conducted in a remote area. However, if nuclear excavation tests or tests of yields above 1 MT or tests away from NTS should be planned, these will be covered by separate environmental statements.

### CIVIL USES

*REFER ALSO TO CITATION(S) 4514*

**5648** **Review of soviet data on the peaceful uses of nuclear explosions.** Nordyke, M.D. (California Univ., Livermore (USA). Lawrence Livermore Lab.). *Ann. Nucl. Energy;* 2: No. 9;10, 657-673(1975).

Over the past several years the Soviet Union has disclosed that it has a very active program for developing peaceful uses of nuclear explosions (PNE) in its national economy. The results of sixteen experimental and industrial explosions designed to develop nine different applications in the petroleum, gas, and minerals industries, as well as for water resources development have been described. However, when the large number of large unidentified seismic events that have been reported over the last seven years in areas of the Soviet Union outside the normal nuclear-weapons test areas are considered, it is obvious that it has an even more active program than has been publicly described, one that must be approaching a routine industrial technology in some areas. The PNE program that the Soviets have publicly discussed in various reports and at various meetings is summarized and, where appropriate, compared with data from the U.S. Plowshare Program.

**5649** **Radionuclide behavior in copper recovery with nuclear explosives.** Arnold, W.D.; Crouse, D.J. (Oak Ridge National Lab., TN). *Trans. Soc. Min. Eng. AIME;* **258**: No. 4, 311-316(Dec 1975).

Fracturing of copper ore for subsequent in-situ leaching and copper recovery was studied with regard to contamination of the copper product and hazards to operating personnel. The solvent extraction process provides a more effective separation of copper from the radioactive contaminants and entails fewer radiation protection problems. Data are shown in graphical, tabular, and equation form.

### WEAPONRY

*REFER ALSO TO CITATION(S) 5189*

## EXPLOSION DETECTION

**5650** (AD-A—012995) **Detection capability of the Kongsberg HGLP-System. Interim scientific report No. 3, 1 Apr 1972—31 Mar 75.** Bruland, L.; Rygg, E. (Bergen Univ. (Norway). Seismological Observatory). 31 May 1975. 46p. NTIS $3.75.

See also report dated 31 May 1974, AD-A—000026.

The surface wave detection capability of the Kongsberg HGLP-system has been investigated for some areas. The detection capability varies strongly from one region to another. The detection threshold for events in Central Asia is on the average at least 0.5 m/sub b/ units higher than for events in Iran-Afghanistan area at about the same epicentral distance. For explosions in the Kazakh area body wave magnitude 5 is required to excite surface wave trains visible at Kongsberg. A phase change of $\pi$ has been found between the Rayleigh wave trains from two presumed underground nuclear explosions in Eastern Kazakh. The Love wave recordings from the same explosions showed unexpectedly large amplitude difference.

# ENVIRONMENTAL SCIENCES, ATMOSPHERIC

*REFER ALSO TO CITATION(S) 6427*

## BASIC STUDIES

**5651** (BNL—21482) **Transport and diffusion using a diagnostic mesoscale model employing mass and total energy conservation constraints.** Meyers, R.E.; Cederwall, R.T.; Ohmstede, W.D.; aufm Kampe, W. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 8p. (CONF-761003—9). Dep. NTIS $3.50.

From Symposium on atmospheric turbulence, diffusion, and air quality; Raleigh, North Carolina, United States of America (USA) (19 Oct 1976).

Several steps are described that have been taken to advance the method of "interpolation" associated with meteorological measurements. These newer methods incorporate some physical constraints into the interpolation. It is the intent of this paper to qualitatively describe early fruits of a joint project at Brookhaven National Laboratory and White Sands Missile Range which has as its objective the formulation of a numerical objective methodology for reconstructing the meteorological fields suitable for the exercise of meso/regional scale transport, chemical and radioactive transformation, and diffusion models.

**5652** (BNL—21598) **Observation of atmospheric internal gravity waves in a turbulent coastal environment.** SathuRaman, S. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 10p. (CONF-760918—1). Dep. NTIS $3.50.

From Conference on coastal meteorology; Virginia Beach, Virginia, United States of America (USA) (21 Sep 1976).

It is fairly well known that during stable atmospheric conditions, waves and turbulence coexist and there is a non-linear interaction between them with the energy being fed from one to another. Identification of waves in flows where turbulence is small is probably not that difficult due to weakly ordered motion of waves as compared to random fluctuations of turbulence. In the atmospheric surface layer where the mechanical turbulence caused by the earth's surface is large, identification of waves is somewhat difficult. This paper describes the observations of internal gravity waves very near the surface (within a height of 24 m) in the surface-based inversion of the marine boundary layer. There are several conflicting features that would probably affect the generation of internal gravity waves in the marine surface layer: nearness of the boundary causes increased turbulence; smooth surface

decreases turbulence; in a large body of water diurnal variation in surface temperature is minimal; and wind generated surface waves contribute to atmospheric turbulence at certain frequencies. (CH)

**5653** (BNWL-SA—5528) **Transport modeling in the environment using the discrete-parcel-random-walk approach.** Ahlstrom, S.W.; Foote, H.P. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). Apr 1976. Contract E(45-11)-1830. 6p. (CONF-760407—4). Dep. NTIS $3.50.

From Conference on environmental modeling and simulation; Cincinnati, Ohio, United States of America (USA) (20 Apr 1976).

When formulating a mathematical model for simulating transport processes in the environment, the system of interest can be viewed as a continuum of matter and energy or as a large set of small discrete parcels of mass and energy. The latter approach is used in the formulation of the Discrete-Parcel-Random-Walk (DPRW) Transport Model. Each parcel has associated with it a set of spatial coordinates as well as a set of discrete quantities of mass and energy. A parcel's movement is assumed to be independent of any other parcel in the system. A Lagrangian scheme is used for computing the parcel advection and a Markov random walk concept is used for simulating the parcel diffusion and dispersion. The DPRW technique is not subject to numerical dispersion and it can be applied to three-dimensional cases with only a linear increase in computation time. A wide variety of complex source/sink terms can be included in the model with relative ease. Examples of the model's application in the areas of oil spill drift forecasting, coastal power plant effluent analysis, and solute transport in groundwater systems are presented.

**5654** (BNWL-SA—5653) **Measured differences in real and apparent plume parameters.** Nickola, P.W. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). May 1976. Contract E(45-1)-1830. 16p. (CONF-761003—5). Dep. NTIS $3.50.

From Symposium on atmospheric turbulence, diffusion, and air quality; Raleigh, North Carolina, United States of America (USA) (19 Oct 1976).

Simultaneous real-time measurements of plume concentration at more than 100 field locations are employed to investigate characteristics of the real (instantaneous) plume. These characteristics are compared to similar characteristics of the apparent (time-integrated) plume. Included in the investigation are contribution of plume meander to apparent plume centerline concentration, peak-to-mean concentration ratios in the real and in the apparent plume, the distribution of 10-sec "real" plume centerline concentrations with respect to the apparent plume centerline concentration, and the deviation in interim plume centerline exposure from the exposure finally experienced at the end of plume passage.

**5655** (BNWL-SA—5669) **Some effects of isentropic vertical motion simulation in a regional scale quasi Langrangian air quality model.** Davis, W.E.; Wendell, L.L. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). May 1976. Contract E(45-1)-1830. 5p. (CONF-761003—12). Dep. NTIS $3.50.

From Symposium on atmospheric turbulence, diffusion, and air quality; Raleigh, North Carolina, United States of America (USA) (19 Oct 1976).

After modifying the transport phase of the constant layer assessment model to include isentropic approximations and doing some preliminary testing, we find the isentropic method to be feasible. We have shown, in case studies, that in frontal storms large discrepancies between the isentropic and the constant layer models can occur in plume position estimates and in the subsequent location and occurrence of wet removal, both in-cloud and below-cloud. In a limited comparison, the model including isentropic considerations was shown to reasonably approximate trajectories on isentropic surfaces. Questions still remain concerning resolution of the layers to more accurately define the saturation of air parcels as well as the inclusion of estimates of diabatic effects. Another vital question yet to be answered is whether the successful inclusion of the isentropic model will be necessary for long-term assessment.

**5656** (COO—2360-3) **Effects of mesoscale weather disturbances on contamination concentrations. Third technical progress report, 1 May 1975—31 July 1976.** Kreitzberg, C.W. (Drexel Univ., Philadelphia, Pa. (USA)). 1976. Contract E(11-1)-2360. 11p. Dep. NTIS $3.50.

The objective of this work is to determine the effect of mesoscale weather disturbances and circulations on air pollution transport and washout on the regional scale. We have completed development of a regional scale numerical weather prediction model that can be run in real time for prediction of air transport and cleansing by precipitation (stable or convective precipitation). The model can also be used for simulation studies of regional trajectory dispersion or for design studies for field experiments that observe regional scale air pollution transport. Extensive tests have been completed on the sensitivity of precipitation (hence, cleansing) to the initial moisture field. Tests are being conducted on the sensitivity of trajectories and trajectory dispersion to model grid resolution. An extensive study is nearing completion on the dynamics of the sea breeze and turbulent forcing at the interface of the water and land atmospheric boundary layers.

**5657** (COO—2455-9) **Model for turbulent diffusion in shear flows.** Kao, S.K. (Utah Univ., Salt Lake City (USA)). Jan 1976. Contract ET(11-1)-2455. 11p. (CONF-761003—18). Dep. NTIS $3.50.

From Symposium on atmospheric turbulence, diffusion, and air quality; Raleigh, North Carolina, United States of America (USA) (19 Oct 1976).

An analysis of the characteristics of the eddy diffusivity is made, and the equations for turbulent diffusion in shear flows are derived. It is shown that the coefficients of the eddy diffusion can be expressed in terms of a characteristic time, the velocity shear of the mean flow, and the variance of the intrinsic turbulent velocity. It is also shown that diffusion equations developed earlier become special cases of the present diffusion model for shear flows.

**5658** (DP-MS—76-5) **Investigation of the bursting process in an atmospheric boundary layer using acoustic methods.** Schubert, J.F.; Pepper, D.W. (Du Pont de Nemours (E.I.) and Co., Aiken, S.C. (USA). Savannah River Lab.). 1976. Contract AT(17-2)-1. 6p. (CONF-761003—10). Dep. NTIS $3.50.

From Symposium on atmospheric turbulence, diffusion, and air quality; Raleigh, North Carolina, United States of America (USA) (19 Oct 1976).

Remote sensing of the atmospheric boundary layer was made in real time with an acoustic sounder to investigate the conditions under which atmospheric momentum bursting occurs. Preliminary sounder data show an abrupt transition from a laminar to a turbulent boundary layer and gravity-wave generation due to shear instability. Data from the acoustic sounder and tethered balloons carrying radiotelemetry are compared to meteorological data obtained at 10 and 137 m on a meteorological tower. Initial sounder data also show that the conditions for the onset of the momentum burst phenomena exist periodically during clear afternoons when heat flux changes sign and the surface begins to cool.

**5659** (UCID—17203) **Modeling of transport in the two-dimensional atmospheric transport and kinetics codes SPHERNEW and TRACER.** Edwards, A. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 23 Jul 1976. Contract W-7405-Eng-48. 31p. Dep. NTIS $4.00.

The report describes how transport by the wind is modeled in the 2-D atmospheric transport and chemical kinetics codes SPHERNEW and TRACER. The description includes the equations for transport by a specified velocity field, the eddy diffusion approximation for short-term fluctuations in the velocity, other simplifying approximations, the geometric grid, the difference equations, and the coefficient matrix of the grid. The assumption of a constant vertical density distribution was used to derive mass-consistent forms of the difference equations. These forms eliminate the instabilities and unrealistic solutions associated with specified wind fields which are not exactly mass-consistent. An option is allowed for variable weighting between central (second-order) and upstream (first-order) forms of the spatial differencing of the advection terms, to modulate phase and amplitude errors in the advection model.

**5660** (UCRL—78120) **Modeling the planetary boundary layer using the Galerkin finite-element method.** Gresho, P.M.; Lee, R.L.; Sani, R.L. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 28 Apr 1976. Contract W-7405-Eng-48. 9p. (CONF-761003—19). Dep. NTIS $3.50.

From Symposium on atmospheric turbulence, diffusion, and air quality; Raleigh, North Carolina, United States of America (USA) (19 Oct 1976).

Finite-element-methods computer programs that approximate the solution to the advection-diffusion equation are discussed for planetary boundary layer modeling. It has application in regional modeling studies and in real-time accident situations relative to air pollution monitoring. (PCS)

**5661** **Cloud condensation nuclei on the Atlantic Seaboard of the United States.** Radke, L.F.; Hobbs, P.V. (Univ. of Washington, Seattle). *Science;* 193: No. 4257, 999-1002(10 Sep 1976).

Concentrations of cloud condensation nuclei measured along the East Coast from Virginia to Long Island ranged from 1000 to 3500 per cubic centimeter as compared to 100 per cubic centimeter in clean maritime air and 300 per cubic centimeter in continental air. The global anthropogenic production rate of cloud condensation nuclei may be comparable to the natural production

rate; in some industrial areas cloud condensation nuclei are dominated by anthropogenic sources.

## CHEMICALS MONITORING AND TRANSPORT

*REFER ALSO TO CITATION(S) 4458, 5479, 5761*

**5662** (AD-A—012070) **Air pollution engineering special study; ambient air quality instrument study, May—December 1974.** Bond, C.A. Jr.; Coats, W.T. (Army Environmental Hygiene Agency, Aberdeen Proving Ground, Md. (USA)). 27 Jun 1975. 50p. (USAEHA—21-020-74/75). NTIS $3.75.

This study provides an evaluation of the accuracy, precision, availability, and simplicity of operation of selected SO2, NO2, and O3 ambient air monitors. A decision weighting model is used to evaluate the characteristics of simplicity of operation, maintainability, data reduction, and calibration. Interference data are also presented for selected instruments. This study does not constitute an endorsement nor rejection by the Department of the Army of any equipment evaluated and/or used. (GRA)

**5663** (BNWL-SA—5654) **Regional scale model for computing deposition and ground level air concentration of $SO_2$ and sulfates from elevated and ground sources.** Wendell, L.L.; Powell, D.C.; Drake, R.L. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). May 1976. Contract E(45-1)-1830. 8p. (CONF-761003—13). Dep. NTIS $3.50.

From Symposium on atmospheric turbulence, diffusion, and air quality; Raleigh, North Carolina, United States of America (USA) (19 Oct 1976).

The model described in this paper is presently in the form of a vehicle to be improved upon. It contains many of the essential elements, in varying degrees of approximation, needed to begin validation and assessment exercises. The approach in this effort has been to maintain a balance between development and application. Validation efforts, assessment exercises and comparisons with other models should suggest the priority of necessary improvement. These efforts are being undertaken, in coordination with other investigators, in an attempt to develop tools for assessing the impact of power plant pollution.

**5664** (DP-MS—76-1) **Comparison of six numerical schemes for calculating the advection of atmospheric pollution.** Long, P.E.; Pepper, D.W. (Du Pont de Nemours (E.I.) and Co., Aiken, S.C. (USA). Savannah River Lab.). 1976. Contract AT(07-2)-1. 8p. (CONF-761003—11). Dep. NTIS $3.50.

From Symposium on atmospheric turbulence, diffusion, and air quality; Raleigh, North Carolina, United States of America (USA) (19 Oct 1976).

Six simple numerical advection schemes for calculating the advection of atmospheric pollutants are compared. These schemes are donor cell (a variant of upwind differencing); fully implicit; Crank-Nicolson; second moment method; quasi-Lagrangian-cubic spline; and chapeau function. The donor cell technique requires the least computation effort, but is the least accurate of the six methods when compared on the basis of artificial dispersion and dissipation. The remaining five schemes require about the same programming effort and computer running time but yield substantially more accurate results. The fully implicit scheme is often less dissipative than the donor cell technique but is still unacceptably inaccurate. Little or no artificial dissipation is manifested by the final four schemes. Numerical calculations with constant and variable advection velocities support these conclusions.

**5665** (N—75-24164) **Interdisciplinary study of atmospheric processes and constituents of the mid-Atlantic coastal region. Attachment 5. Data set for background investigation of atmospheric constituents for Richmond, Virginia area.** Kindle, E.C.; Bandy, A.; Copeland, G.; Blais, R.; Levy, G. (Old Dominion Univ., Norfolk, Va. (USA). Research Foundation). May 1975. Contract NGR-47-003-067. 108p. (NASA-CR—142822). NTIS $5.25.

Background data is provided for the photochemical oxidant problem in the Richmond area. Particulate data, digitized portrayal of site molecular and meteorological data, and graphical portrayal of molecular data, hourly meteorological data, and streamflow charts and radiosonde data are also given. (GRA)

**5666** (NSF—75-403) **Fluorocarbons and the environment. Report of Federal Task Force on Inadvertent Modification of the Stratosphere (IMOS).** (Council on Environmental Quality, Washington, D.C. (USA)). Jun 1975. 114p. Dep. NTIS $5.50.

The report consists of an executive summary, which is an abstract of the whole report; a conclusions and Federal actions section addressing the magnitude and nature of the potential problem and the proposed Federal program of action; and more detailed sections treating the scientific findings concerning the stratospheric, agricultural and biological effects of ozone reduction, human health effects, and industrial and economic considerations. The stratospheric effects section (III) is based on a more detailed report by the Interdepartmental Committee for Atmospheric Sciences (The Possible Impact of Fluorocarbons and Halocarbons on Ozone, Report No. 18a), which is available through the Executive Secretary of ICAS, Room 312, National Science Foundation, 1800 G Street N.W., Washington, D.C. 20550.

**5667** (PB—241507) **Effects of air pollutants on textile fibers and dyes. Final report.** Upham, J.B.; Salvin, V.S. (North Carolina Univ., Greensboro (USA)). Feb 1975. Contract PH-22-68-2. 88p. NTIS $4.75.

This document presents: (1) a comprehensive survey of the damaging effects of air pollutants - particulates, SOx, NOx, and ozone - on textile fibers and dyes, and (2) the results and assessment of a public opinion survey to primarily measure consumer awareness of the detrimental effects of air pollution on household textile products. Nearly 100 references are cited and many of the research investigations are detailed and discussed. The survey found that air pollution represents a significant problem area for the textile industry and many consumers. The public opinion survey revealed that consumer awareness of the major air pollution effects on household textile products is poorly established and generally lacking. (GRA)

**5668** (PB—242075-01/SL) **EPA reports bibliography quarterly. A listing of EPA reports entered into the National Technical Information Service, January, February, March 1975.** (Environmental Protection Agency, Washington, D.C. (USA)). 1975. 84p. NTIS $15.00.

See also PB—238800. Also available on subscription $45.00/domestic, $60.00/foreign.

The quarterly bibliography series supplements the original one (EPA-LIB-73-01; PB-223 693) dated July 1973 and the first supplement (EPA-LIB-74-03; PB-234 215) dated August 1974, and the second supplement (PB-238 800) dated December 1974. It contains citations, abstracts and author, corporate source, subject, contract, and title indexes for all U.S. Environmental Protection Agency and its predecessor agencies' reports entered into the NTIS collection in the period noted. (GRA)

**5669** (UCID—17243) **Statistical comparisons of Savannah River anemometer data applied to quality control of instrument networks.** Porch, W.M.; Dickerson, M.H. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Aug 1976. Contract W-7405-eng-26. 29p. Dep. NTIS $4.00.

Continuous monitoring of extensive meteorological instrument arrays is a requirement in the study of important mesoscale atmospheric phenomena. The phenomena include pollution transport prediction from continuous area sources, or one time releases of toxic materials and wind energy prospecting in areas of topographic enhancement of the wind. Quality control techniques that can be applied to these data to determine if the instruments are operating within their prescribed tolerances were investigated. Savannah River Plant data were analyzed with both independent and comparative statistical techniques. The independent techniques calculate the mean, standard deviation, moments about the mean, kurtosis, skewness, probability density distribution, cumulative probability and power spectra. The comparative techniques include covariance, cross-spectral analysis and two dimensional probability density. At present the calculating and plotting routines for these statistical techniques do not reside in a single code so it is difficult to ascribe independent memory size and computation time accurately. However, given the flexibility of a data system which includes simple and fast running statistics at the instrument end of the data network (ASF) and more sophisticated techniques at the computational end (ACF) a proper balance will be attained. These techniques are described in detail and preliminary results are presented. (CH)

**5670** (UCRL—51930(Vol.3)) **Environmental effects of energy production and utilization in the U.S. Volume 3. Techniques for controlling emissions.** Newkirk, H.W. (comp.). (California Univ., Livermore (USA). Lawrence Livermore Lab.). 14 Jun 1976. Contract W-7405-eng-48. 80p. Dep. NTIS $5.00.

Technological, social, economic and political techniques for controlling emission are summarized for environmental pollutants introduced into air, water and land resources. Chemical, radiological and physical factors are discussed. (PCS)

**5671** **Effect of atmospheric sulfur dioxide on the pH of rain intercepted by forest trees.** Baker, J.; Hocking, D.; Nyborg, M. pp 98-102 of In Proceedings of workshop on sulfur gas research. Edmonton, Alberta; Canadian Forestry Service (1973).

From Proceedings of workshop on sulfur gas research; Edmonton, Alberta, Canada (1 Nov 1973).

Eight collection sites were established up to 8 mi from a gas processing plant which emits up to 84 long tons of sulfur dioxide per day in a lodgepole pine-dominated forest. Three control sites were established 10-12 mi upwind from the plant. Rainfall was collected in clearings and in immediately adjacent stands of lodgepole pine. Analyses were performed on samples for pH and sulfate levels. The average pH value of rain was 0.6 pH units lower than that of the control sites. The pH values of both throughfall and stemflow were 1.8 units lower at the sites near the plant than at the control sites on the average. These results were obtained from Aug. 17 to Aug. 30. Intercepted rain was consistently higher than open rain in total sulfate content. The increased acidity of intercepted rain could have been due to the adsorption of emitted $SO_2$ on the surface of needles and/or tree bark. Data on sulfate content were consistent with this hypothesis, but not yet supportive of it due to the deficiency in analytical method. The $SO_2$ emissions did acidify intercepted rain more than open rainfall which may help explain the fate of some $SO_2$. Stemflow was the most acid. The impact of the very acid stemflow on soil acidity would likely be limited to an extremely small area at the base of the tree. Emissions in forests may be adsorbed and later washed off in intercepted rain.

**5672 Two-dimensional model for the transport of pollutants in an urban basin.** Liu, C.Y.; Goodin, W.R. (Univ. of California, Los Angeles). *Atmos. Environ.;* **10**: No. 7, 513-526(1976).

The distribution of an inert chemical species, carbon monoxide (CO), emitted mainly from automobile exhaust is investigated. The transport model, in analogy with the shallow water theory in fluid dynamics, considers variation of all physical quantities in the horizontal direction below the temperature inversion layer. Pollutants are found to be carried primarily by the wind; turbulent diffusion in a normal day plays only a minor role. The concentration of CO predicted by the present model for the entire Los Angeles basin is compared with observed data at nine stations. Accuracy of four different numerical schemes, the effect of turbulent diffusivity, and the source strengths are examined.

**5673 Elution of benzo[a] pyrene from carbon particles in the respiratory tract of mice.** Creasia, D.A.; Poggenburg, J.K. Jr.; Nettesheim, P. (Oak Ridge National Lab., TN). *J. Toxicol. Environ. Health;* 1: No. 6, 967-975(Jul 1976).

The effect of carrier particle size on the rate of dissociation of benzo[a]pyrene (BaP) from carrier particles deposited in the respiratory tract of mice was studied. BaP-coated carbon particles (in two size ranges, 0.5-1.0 and 15-30 $\mu$m) plus $^{103}$Ru-tagged carbon tracer particles were intratracheally instilled in mice. The clearance of carbon particles and the simultaneous rate of elimination of BaP from the respiratory tract was measured. BaP adsorbed to 15- to 30$\mu$m carbon particles was eliminated from the lung at essentially the same rate as the carbon particles were cleared. In contrast, BaP adsorbed to 0.5- to 1.0-$\mu$m carbon particles was eliminated from the lung approximately 4 times faster than the carbon particles were cleared. The persistence of carcinogens and their rates of elution from carrier particles are discussed in relation to the pathogenesis of lung cancer in animals treated with carcinogen-carrier particle preparations.

## RADIOACTIVE MATERIALS MONITORING AND TRANSPORT

*REFER ALSO TO CITATION(S) 5612, 5613, 5669, 5670*

**5674** (BNWL—2047) **Estimation of air concentrations due to the suspension of surface contamination by the wind.** Horst, T.W. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). Mar 1976. Contract E(45-1)-2130;E(45-1)-1830. 49p. Dep. NTIS $4.00.

A mathematical model is developed for the calculation of air concentrations of material suspended by the wind from areas of surface contamination and the model is applied specifically to the BC Controlled Area. Example computer solutions are given to show the dependence of the suspended air concentration on suspension rate, deposition velocity, wind speed, wind direction and atmospheric stability. This model is subsequently simplified to produce an analytical method for the economical estimation of air concentrations and horizontal fluxes of suspended surface contamination. The predictions of the analytical method are demonstrated to agree quite well with those of the more complex, computerized model.

**5675** (NVO—159) **Studies of environmental plutonium and other transuranics in desert ecosystems. Nevada Applied Ecology Group progress report (workshop session, May 1975).** White, M.G.; Dunaway, P.B. (eds.). (Energy Research and Development Administration, Las Vegas, Nev. (USA). Nevada Operations Office). Mar 1976. 196p. (CONF-750548—). Dep. NTIS $7.50.

From Information meeting of the applied ecology group; Las Vegas, Nevada, USA (6 May 1975).

Data are reported from measurements of the content of Pu in soil samples from various locations at the Nevada Test Site; the content of $^{236}$U, $^{233}$U, $^{234}$U, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{90}$Sr, $^{241}$Am, $^{60}$Co, and $^{137}$Cs in soil and vegetation samples from the Nevada Test Site; mechanisms for the transport of $^{238}$Pu and other transuranics from soil through food chains involving grazing cattle and man; the distribution of $^{239}$Pu and $^{241}$Am in the tissues of wild rodents living on the Nevada Test Site; the role of soil microorganisms in the transport of Pu through desert ecosystems; Pu content in samples of soil, air, water, and plants collected in the vicinity of the Nevada Test Site during 1975; measurements of the content of $^{239}$Pu in resuspended desert particles collected at various locations at the Nevada Test Site; and the development of sampling and statistical methods for monitoring radioactivity in environmental samples from the Nevada Test Site and Tonopah Test Range. (CH)

**5676** (PB—243256) **Activities and needs related to radioactivity standards for environmental measurements. Symposium held in Washington, DC, August 21, 1973.** Eldridge, J.E.; Kahn, B. (eds.). (Oak Ridge National Lab., Tenn. (USA)). Jun 1975. Contract W-7405-eng-26. 62p. (CONF-730871—; EPA—670/4-75-006). Dep. NTIS $4.50.

From Symposium on activities and needs related to radioactivity standards for environmental measurements; Washington, District of Columbia, United States of America (USA) (21 Aug 1973).

A symposium was held to discuss the needs for radioactivity standards in environmental monitoring programs concerned with population radiation exposure. Papers were presented on Status of Decay Schemes, Some Activities and Needs for AEC Regulatory in the Use of Radioactivity Standards, Standards for Environmental Studies, Program and Activities of the Quality Assurance Branch, NERC-Las Vegas, Activities of Commercial Radionuclide Producers, and Radionuclide Metrology and Quality Assurance. The presentations indicated that numerous radioactivity standards and aids for correctly utilizing them were available. New needs because lower levels of ambient radioactivity must be measured by many more groups due to requirements that population radiation exposure from nuclear power production be as low as practicable are discussed. Based on the presentations and resulting discussions, the following actions were recommended: establish a focal point for systematically planning activities to meet cited needs for decay schemes, specific standards, analytical methods, and quality assurance programs; develop a clear chain of traceability to the National Bureau of Standards; prepare guides for standardizing radiation detection and maintaining quality control; and train qualified analysts to obtain satisfactory analytical results.

**5677** (PB—243636/8ST) **Environmental radioactivity laboratory intercomparison studies program, 1975. Environmental monitoring series.** (National Environmental Research Center, Las Vegas, Nev. (USA)). May 1975. 27p. (EPA—680/4-75/002b). NTIS $3.75.

See also PB—240962.

The U.S. Environmental Protection Agency's intercomparison studies program for laboratories involved in environmental radiation measurements is described. The types of environmental samples distributed, the analysis required for each sample, the distribution schedule, and the statistical analysis and reporting of results are discussed. Instructions and application forms are included for laboratories desiring to participate in the program. This document is not a research report. It is designed for use by laboratories participating or desiring to participate in this quality assurance program. (GRA)

**5678 Xenon-133: ambient activity from nuclear power stations.** Kunz, C.O.; Paperiello, C.J. (New York State Dept. of Health, Albany). *Science;* **192**: No. 4245, 1235-1237(18 Jun 1976).

The average activity of xenon-133 within and at approximately 100 kilometers from Albany, New York, from April to July 1975 was 2.6 picocuries per cubic meter of air. The source was gaseous effluents from boiling water reactors located in the northeastern United States. Its 5.29-day half-life makes xenon-133 an appropriate isotope to observe for the study of regional and hemispheric dispersion of pollutants.

**5679 Rapid method for preparation of nuclear membranes from mammalian cells.** Hildebrand, C.E.; Okinaka, R.T. (Los

Alamos Scientific Lab., NM). *Anal. Biochem.*; 75: No. 1, 290-300(Sep 1976).

A simple, rapid procedure for disrupting nuclei of mammalian cells has been characterized. This procedure involves treating isolated nuclear suspensions with the natural polyanion heparin in 0.125 M sucrose buffered between pH 7.0 and 8.0. The rate and extent of nuclear lysis are dependent upon the ratio of nuclei concentration to heparin concentration. This procedure avoids use of intense mechanical disruption, enzymatic digestion, and high salt concentrations for achieving optimum lysis of the nuclei. This method can also be used for large-scale nuclear membrane preparations.

## SITE RESOURCE AND USE STUDIES

**5680** (ERDA—1550-D) **High Performance Fuel Laboratory, Hanford Reservation, Richland, Washington.** (Energy Research and Development Administration, Washington, D.C. (USA)). Sep 1976. vp. USERDA, Washington, DC.

In compliance with NEPA, this draft environmental statement was prepared to support the liquid metal fast breeder reactor program. The facility will be used to develop and demonstrate safe and economic manufacturing processes for fuels comprising oxides of plutonium and uranium. Four alternatives to the construction of this facility were considered. Fifteen government agencies are asked for written comments on the statement. (PCS)

## REGULATIONS

*REFER ALSO TO CITATION(S) 5297*

**5681** (BNL—21654) **Analysis of emission charges as a method of reducing sulfur pollution.** Wilson, D.G.; Chen, P.W. (Massachusetts Inst. of Tech., Cambridge (USA). Dept. of Mechanical Engineering). Jun 1976. Contract E(30-1)-16. 106p. Dep. NTIS $5.50.

For Brookhaven National Lab., Upton, NY.

Requiring sulfur polluters to make payments which are functions of the emissions discharged (the "polluter-pay-principle") is a method of regulation which is an alternative but not an equivalent to the setting of sulfur-emission standards and the punishing of those who permit the emission of the facilities under their control to exceed these standards. It is shown that this approach gives greater incentives toward the rapid reduction of sulfur emissions than does the setting of standards, particularly when the charges are adjusted to represent estimates of the health and property damage resulting from the emissions. Some variations of an extension of the polluter-pay-principle are also examined.

**5682 Lead-based paint poisoning prevention in HUD-associated housing and federally owned property to be sold for residential habitation.** *Fed. Regist. (Wash., D.C.)*; 41: No. 135, 28876-28881(13 Jul 1976). (24CFR35).

From Housing and Urban Development, 24CFR35, Office of the Secretary, Department of Housing and Urban Development—Lead-based paint poisoning prevention in HUD-associated housing and federrally owned property to be sold for residential habitation.

Proposed revisions to Part 35 of this chapter regarding lead-based paint poisoning prevention in order to implement the provisions of section 302 of the Lead-Based Paint Poisoning Prevention Act, Pub. L. 91-695, as amended by Pub. L. 93-151, (42 U.S.C. 4801, et seq.) are presented.

**5683 Selective enforcement auditing procedures.** *Fed. Regist. (Wash., D.C.)*; 41: No. 146, 31472-31502(28 Jul 1976). (40CFR86).

From Protection of Environment, 40CFR86, Environmental Protection Agency—Control of air pollution from new motor vehicles and new motor vehicle engines.

These regulations establish an emissions testing program for new automobiles coming off the assembly line in order to ensure that these vehicles conform to the pollution control requirements of the Clean Air Act. This program will be known as "Selective Enforcement Auditing" or "SEA."

# ENVIRONMENTAL SCIENCES, TERRESTRIAL

## BASIC STUDIES

**5684** (ORNL/RUS—18) **REGRID: a generalized grid-to-grid transformation procedure.** Mashburn, R.G.; Durfee, R.C.; Edwards, R.G. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 79p. Dep. NTIS $5.00.

In recent years geographical information has been collected and digitized for many different regions in the United States. The most common representation of such data has been through the use of grid systems in which the region is broken up into a large number of cells. Since there is a significant number of different geographical coordinate systems and map projections in existence, digitized information exists over the country in a number of different grid systems. In order to merge and analyze spatially distributed data digitized in these different systems, a transformation from one grid to another must be performed. This report describes a generalized technique for grid-to-grid transformation in which a variety of data representations are allowed. Although the procedure was developed for problems in environmental and regional analysis, it is also applicable to non-geographic problems such as heat transfer mesh problems.

## CHEMICALS MONITORING AND TRANSPORT

*REFER ALSO TO CITATION(S) 5668, 5670*

**5685** (AD-A—012109) **Environmental protection guidelines for the resident engineer. Final report.** Riggins, R.E. (Army Construction Engineering Research Lab., Champaign, Ill. (USA)). May 1975. 43p. (CERL-TR-E—57). NTIS $3.75.

This report presents guidelines to assist resident engineers in monitoring compliance with the environmental provisions of construction contracts. It describes general environmental responsibilities of the resident engineer; sources of environmental pollution; techniques for providing environmental protection; and methods of evaluating a construction site for potential environmental problems. (GRA)

**5686** (PB—243509) **Movement of pollutant phosphorus in unsaturated soil. Final report, 1 Jul 1971—30 Jun 1974.** Monke, E.J.; Millette, E.D.; Huggins, L.F. (Purdue Univ., Lafayette, Ind. (USA). Water Resources Research Center). Jun 1974. 49p. NTIS $3.75.

The report discusses research whose primary objective was to determine the functional relationships between soil, soil water content, and phosphorus concentration capacities in a laboratory system similar to the irrigation of waste water on land. Various concentrations of potassium phosphate solution were admitted to short soil columns on reaction chambers. The phosphate solution also contained a radioactive tracer which was chemically the same as the major portion of the solute. After reaction with a given soil mixture, the effluent was collected at known time intervals and the amount of phosphate removed for the time intervals were determined. The Freundlich and Langmuir isotherm equations did not account for differences in soil water pressure and being equilibrium equations neither did they account for time at equilibrium. An exponential equation similar to that of Freundlich is proposed in which soil water pressure as well as time are taken into account. In an unsaturated state, soil water pressure tends to drain the large soil pores first and the flow lines are diverted into the small pores where more adsorptive surfaces are available. (GRA)

## RADIOACTIVE MATERIALS MONITORING AND TRANSPORT

*REFER ALSO TO CITATION(S) 5613, 5670, 5675*

**5687** (COO—1156-84) **Radioecology of natural systems in Colordao. Fourteenth annual progress report, May 1, 1975—July 31, 1976.** Whicker, F.W. (Colorado State Univ., Fort Collins (USA). Dept. of Radiology and Radiation Biology). 1 Aug 1976. Contract E(11-1)-1156. 71p. Dep. NTIS $4.50.

This report summarizes project activities during the period May 1, 1975 through July 31, 1976. The major study on the distribution and levels of Pu in major components of the terrestrial ecosystem at Rocky Flats was completed. Supportive studies on

the ecology and pathology of small mammals and their role in Pu transport were essentially completed as well. Detailed studies on mule deer food habits, population dynamics, and movements at Rocky Flats are progressing. These studies are designed to measure the potential of mule deer in transporting Pu to uncontrolled areas. Alpha autoradiographic studies designed to measure Pu particle size and distribution and spatial patterns in soil were initiated. Field and greenhouse transport pathways from soil to vegetation are in progress and some early results reported. The status of studies on seasonal kinetics of Cs in a montane lake and stable lead geochemistry in an alpine lake watershed are also reported.

**5688** (EGG—1183-1642) **Radiological survey of the area surrounding Arkansas Nuclear One, Russellville, Ark. Date of survey: 31 May—2 June 1973.** (EG and G, Inc., Las Vegas, Nev. (USA)). 1 Nov 1974. Contract AT(29-1)-1183. 23p. Dep. NTIS $3.50.

The Aerial Radiological Measuring System (ARMS) was used to perform an aerial radiological survey of the area surrounding the Arkansas Nuclear One Power Station from May 31 through June 2, 1973. The terrestrial background gamma radiation was measured during the survey.

**5689** (ORNL/EIS—91) **Environmental aspects of the transuranics: a selected, annotated bibliography.** Fore, C.S.; Martin, F.M.; Faust, R.A. (comp.). (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 204p. (NVO/AEIC—76/1). Dep. NTIS $7.75.

This bibliography of 500 references is compiled from the Data Base on the Environmental Aspects of the Transuranics built to provide information support to the Nevada Applied Ecology Group (NAEG) of ERDA's Nevada Operations Office. The general scope is environmental aspects of uranium and the transuranic elements, with emphasis on plutonium. Laboratory and field studies dealing with the effects of plutonium-239 on animals are highlighted in this bibliography. Supporting information on ecology of the Nevada Test Site and reviews on the effects of other radionuclides upon man and his environment has been included at the request of the NAEG. The references are arranged by subject category with first authors appearing alphabetically in each category. Indexes are given for author, geographic location, keywords, taxons, permuted title and publication description.

**5690** (PB—242983) **Radioactivity in construction materials a literature review and bibliography. Technical note (final).** Eadie, G.G. (Environmental Protection Agency, Las Vegas, Nev. (USA). Office of Radiation Programs). Apr 1975. 50p. (ORP/LV—75-1). NTIS $3.75.

Surveys to determine the radioactive content of specific building materials used in the United States have not been reported in the literature. The external dose to the U.S. population from exposure to natural radioactive materials (exclusive of uranium mill tailings) contained in U.S. building materials has not been evaluated, and the possibly significant external exposure from the use of by-product gypsum and fly-ash materials should be evaluated. The effects of various construction materials on the attenuation of cosmic and terrestrial radiations have been evaluated in a limited number of surveys in the urban areas of Boston, New York, and Livermore, California. The measurement of radon and radon daughter product concentrations has only been reported for a few dwellings and several multi-story office buildings in Boston and in several State-owned buildings in North Carolina. This literature search has found a lack of meaningful data for use in evaluating the U.S. population exposure from building materials. (GRA)

**5691** **Simultaneous collection of americium and plutonium from environmental samples.** Knab, D. (Los Alamos Scientific Lab., NM). *Trans. Am. Nucl. Soc.*; 23: 598(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

### TERRESTRIAL ECOSYSTEMS AND FOOD CHAINS

*REFER ALSO TO CITATION(S) 4597, 5675, 5676, 5687, 5689*

## SITE RESOURCE AND USE STUDIES

*REFER ALSO TO CITATION(S) 5238, 5680, 5687, 5688, 5706, 5769*

**5692** (RLO—2225-T39-1) **Micro-earthquake monitoring of the Hanford region. Annual progress report.** (Washington Univ., Seattle (USA)). 30 Mar 1976. Contract E(45-1)-2225. 63p. Dep. NTIS $4.50.

In July, 1975 the University of Washington assumed responsibility for the seismic network in eastern Washington. This network consists of 29 vertical seismograph stations plus three horizontal components. The entire network is broken down into two sub-nets. The Hanford Net consists of 16 stations, located on or near the Hanford Reservation and south of Smyrna, and enables the procurement of epicenter locations of all earthquakes of magnitude 1.0 and greater within the Hanford Reservation. North of this network is the Central Net, which consists of 13 stations, two of which (Vantage and Warden) are closely spaced at the north edge of the Hanford Net. The eleven remaining stations are spaced farther apart, to the north, in order to obtain a regional seismic picture of the entire eastern Washington area. All earthquakes between July 1975 and January 1976 that have instrumentally-determined epicenters are listed, including date, shock, time, location, depth, magnitude, and all stations that were used in the epicentral determinations and their arrival times. (CH)

# ENVIRONMENTAL SCIENCES, AQUATIC

*REFER ALSO TO CITATION(S) 6427*

## BASIC STUDIES

**5693** (ANL/ES—40(Vol.16)) **Environmental status of the Lake Michigan region. Volume 16. Amphibians and reptiles of the Lake Michigan drainage basin.** Pentecost, E.D.; Vogt, R.C. (Argonne National Lab., Ill. (USA)). Jul 1976. Contract W-31-109-ENG-38. 69p. Dep. NTIS $4.50.

The focus of this report is on regional distribution of the herpetofauna of the Lake Michigan Drainage Basin. The introduction includes a brief discussion of plant communities and their associated herpetofauna, and the importance of hibernacula and migration routes. Some aspects of the status, distribution, habitat, and life history of the amphibians and reptiles of the Basin are described in an annotated checklist. Special attention is given to uncommon and endangered species. Species range is shown on distribution maps.

**5694** (COO—1332-121) **Movements and behavior of largemouth bass (Micropterus salmoides) and steelhead (Salmo gairdneri) determined by radio telemetry.** Winter, J.D. (Minnesota Univ., Minneapolis (USA)). Aug 1976. Contract E(11-1)-1332. 200p. Dep. NTIS $7.50.

Thesis.

The organization of this thesis reflects the development of underwater radio tracking methodology for monitoring movements of freshwater fish. Equipment and techniques developed during this research are described in Part I and represent a cooperative effort between the author and the University of Minnesota's Cedar Creek engineering staff. In 1970, the equipment and techniques were tested and perfected during a study of largemouth bass movements in Mary Lake. The bass project provided an ideal situation to test the system. Since Mary Lake was small and the bass exhibited localized movements, the fish could be found easily; consequently, the performance of the system could be continually analyzed and problems could be quickly solved. The home range movements of the bass are described in Part II. After establishing the reliability and usefulness of the system, a much more difficult project was attempted. In 1971, a program was initiated to study the movements and behavior of steelhead in western Lake Superior. Results of this project (1971 to 1974) are presented in Part III.

**5695** (COO—2185-10) **New York Bight and Hudson Canyon in October 1974: hydrography, nephelometry, bottom photograpy, currents. VEMA Cruise 32 Leg 1 data.** Amos, A.F. (Columbia Univ., Palisades, N.Y. (USA). Lamont-Doherty Geological Observatory). Jul 1976. Contract E(11-1)-2185. 193p. Dep. NTIS $7.50.

This report presents data collected in the last two weeks of October 1974 from Lamont-Doherty Geological Observatory's research vessel VEMA during the first of a series of cruises designed to examine the seasonal variations in the physical oceanography and geochemistry of the New York Bight. The physical oceanography data includes the hydrography, nephelometry, bottom photography, and currents. The aim of the project is to understand the interaction between shelf, slope and oceanic waters and the mechanisms that determine the fate of energy-related pollutants in the New York Bight.

**5696** (COO—3573-14) **Uranium-series radionuclides as tracers of geochemical processes in Long Island Sound.** Benninger, L.K. (Yale Univ., New Haven, Conn. (USA). Dept. of Geology and Geophysics). May 1976. Contract E(11-1)-3573. 163p. Dep. NTIS $6.75.

Thesis.

An estuary can be visualized as a membrane between land and the deep ocean, and the understanding of the estuarine processes which determine the permeability of this membrane to terrigenous materials is necessary for the estimation of fluxes of these materials to the oceans. Natural radionuclides are useful probes into estuarine geochemistry because of the time-dependent relationships among them and because, as analogs of stable elements, they are much less subject to contamination during sampling and analysis. In this study the flux of heavy metals through Long Island Sound is considered in light of the material balance for excess $^{210}Pb$, and analyses of concurrent seston and water samples from central Long Island Sound are used to probe the internal workings of the estuary.

**5697** (RLO—2227-T12-62) **Distribution pattern of holothurians on the Northeastern Pacific (Oregon, U.S.A.) continental shelf, slope, and abyssal plain.** Carney, R.S.; Carey, A.G. Jr. (Oregon State Univ., Corvallis (USA). Dept. of Oceanography). 1975. Contract E(45-1)-2227. 18p. (CONF-7509142—1). Dep. NTIS $3.50.

From 2. echinoderms conference; Rovinj, Yugoslavia (26 Sep 1975).

Between 135 degrees W. Long. and the Oregon coast there are four bathymetric provences: Tuft's Abyssal Plain (3500 to 4000 m), Cascadia Basin (3000 to 2000 m), the continental slope (2000 to 200 m), and the continental shelf above 200 m. During extensive trawling in this area approximately 15,000 specimens from 33 species of holothurians have been collected. On the basis of vertical ranges the shelf and slope each correspond to a faunal zone, and Tuft's Plain combines with Cascadia Basin to form a third faunal zone. Each half of this deepest zone has a distinct pattern of dominant species. Faunal changes seen in three transects taken on Cascadia Basin suggest that proximity to land is less important than depth in determining the composition of the holothurian fauna. The species collected below shelf depths agreed with those collected by the "Albatross" between the equatorial Pacific and San Diego, California.

**5698** (SRO—901-1) **Management: southeast continental shelf studies.** Menzel, D.W. (Skidaway Inst. of Oceanography, Savannah, Ga. (USA)). Aug 1976. Contract E(38-1)-901. 12p. Dep. NTIS $3.50.

Progress is reported on oceanographic studies in the Southeast Atlantic. Results are summarized for a study of physical oceanographic factors forcing water motion on the continental shelf and the origin of Gulf Stream intrusions; the physical oceanography of intrusions once isolated from the Gulf Stream; nutrient fluxes induced by and chemical characterization of intrusions; the effects of intrusions and coastal circulation on microorganisms, phytoplankton, and zooplankton; heavy metal distribution and inputs into coastal waters; radioisotope geochemistry; and uptake and discharge of pollutants by marine organisms. (CH)

## RADIOMETRIC TECHNIQUES

**5699** (AD-A—014168) **Use of the radioisotopic sand tracer (RIST) system. Technical memo.** Judge, C.W. (Coastal Engineering Research Center, Fort Belvoir, Va. (USA)). Jun 1975. 76p. (CERC-TM—53). NTIS $4.75.

The Coastal Engineering Research Center (CERC), under a multiagency program initiated in 1966, has developed a synoptic sand tracing system capable of operating on the beach, in the surf zone, and offshore. This system has application in determining sediment movement along coastal areas. Some specific problems to which the system can be applied are: (a) Mechanisms of sediment movement; (b) improving beach fill criteria; (c) relation of engineering structures to sediment transport; and (d) movement of disposal materials. Sand of the desired size characteristics is plated with gold 198-199 isotopes and sealed in water soluble packets. The packets are injected in the water as either line or point sources by extrusion from the carrier-injection device. Surveying is conducted from an amphibious vehicle (LARC) which tows a ball-like device containing four scintillation detectors. Signals from the detectors are transmitted by cable to the onboard data collection system. The system also collects other data (e.g., navigation, fathometer, etc.) pertinent to surveying; this data is telemetered to a shore-based PDP-8 computer system for field processing. Processed data are plotted on the cathode ray tube (CRT) real-time data display and stored on magnetic tape for further analysis. Data obtained with the RIST system represent nearly synoptic observation of sediment transport within one or all of the nearshore environmental zones over a wide area. (GRA)

## CHEMICALS MONITORING AND TRANSPORT

*REFER ALSO TO CITATION(S) 5653, 5668, 5670, 5686, 5695, 5698, 5759*

**5700** (COO—3573-15) **Geochemistry of manganese, iron, uranium, lead-210 and major ions in the Susquehanna River.** Lewis, D.M. (Yale Univ., New Haven, Conn. (USA). Dept. of Geology and Geophysics). 1976. Contract E(11-1)-3573. 284p. Dep. NTIS $9.25.

Thesis.

The change in water composition accompanying a change in discharge of large streams and the Susquehanna River results from the change in the proportions of the total flow composed of type waters of constant composition. This change in the flow proportions is due to the different hydrologic responses to precipitation inputs of basins underlain by different single rock types. The in-river precipitation of mine-drainage-injected Mn and Fe was studied at a pH of approximately 7. For Mn the removal from solution appears to be first order. The rate constant is $10^3$ times greater than the extrapolated autocatalytic rate constant of previous laboratory experiments. The study of the removal of Fe from solution yields a first order rate constant consistent with previous laboratory experiments. Lead-210 was used as a natural tracer to study the fate of trace metals.

**5701** (N—75-22938) **Application of vascular aquatic plants for pollution removal, energy, and food production in a biological system.** Wolverton, B.C.; Barlow, R.M.; Mcdonald, R.C. (National Aeronautics and Space Administration, Bay St. Louis, Miss. (USA). National Space Technology Labs.). 12 May 1975. 17p. (NASA-TM-X—72726). NTIS $3.25.

Vascular aquatic plants such as water hyacinths (Eichhornia crassipes) (Mart.) Solms and alligator weeds (Alternanthera philoxeroides) (Mart.) Griesb., when utilized in a controlled biological system (including a regular program of harvesting to achieve maximum growth and pollution removal efficiency), may represent a remarkably efficient and inexpensive filtration and disposal system for toxic materials and sewage released into waters near urban and industrial areas. The harvested and processed plant materials are sources of energy, fertilizer, animal feed, and human food. Such a system has industrial, municipal, and agricultural applications. (Author) (GRA)

**5702** (PB—241905) **Development document for effluent limitations guidelines and new source performance standards for the major organic products segment of the organic chemicals manufacturing point source category. Final report.** Nardella, J. (Environmental Protection Agency, Washington, D.C. (USA). Effluent Guidelines Div.). Apr 1974. 378p. (EPA—440/1-74-009-a). NTIS $10.25.

See also report dated Mar 1974, PB—238611.

A study of the major organic chemicals segment of the organic chemicals manufacturing industry was conducted. The purpose of this study was to establish effluent limitations guidelines for existing point source discharges and standards of performances and pretreatment standards for new sources. 41 major product-process segments of the industry were investigated. These product-processes and other significant segments to be covered in the second phase of this study were categorized into four subcategories based on process technology as related to process water requirements. The industry is not readily defined in terms of the Standard Industrial Classification (SIC) system. However, commodities included under SIC 2815 (Cyclic Intermediates and Crudes) and SIC 2818 (Industrial Organic Chemicals) provide a reasonable approximation and have been used to define the limitations of the industry for the current study. Primary petrochemical processing, plastics, fibers, agricultural chemicals, pesticides, detergents, paints, and pharmaceuticals have been excluded. Processes, wastes, control technology, and costs are discussed. (GRA)

**5703** (RLO—2225-T24-18) **Chemical and geochemical studies off the coast of Washington. Report of progress, May 1974—May 1975.** Carpenter, R. (comp.). (Washington Univ., Seattle (USA). Dept. of Oceanography). May 1975. Contract AT(45-1)-2225-T24. 23p. Dep. NTIS $3.50.

Results are reported from studies on the chemical, geological, and geochemical effects of the Columbia River in the northeast Pacific Ocean from May 1974 to May 1975. The studies followed three main lines of investigation: surface chemical studies of the scavenging of various species dissolved in sea water, especially lead-210, by well characterized natural particulates; studies of uptake and transfer of several isotopes, starting with polonium-210, by particularly well defined parts of the marine food web; and studies of the behavior of lead-210 and polonium-210 in sediments off the Washington coast and the application of lead-210 dating to

determine sediment accumulation rates over the past 100 years in the coastal zone. (auth)

**5704 Analytical characterization of water-treatment-plant sludge.** Schmitt, C.R. (Union Carbide Corp., Oak Ridge, TN); Hall, J.E. *J. Am. Water Works Assoc.*; 67: No. 1, 40-42(Jan 1975).

Spark-source mass-spectrographic analysis was used to characterize samples of alum-coagulated sludge at the water-treatment plant in Oak Ridge, Tenn. The sludge solids contained a heterogenous mixture of materials, including organic and nonorganic compounds, soil, and fly-ash particulates. Analyses showed the presence of many elements.

**5705 Mercury content of biota in coastal waters in Hawaii.** Klemmer, H.W. (Univ. of Hawaii, Honolulu); Unninayer, C.S.; Okubo, W.I. *Bull. Environ. Contam. Toxicol.*; 15: No. 4, 454-457(Apr 1976).

A survey of mercury and pesticide residue content of biota collected from four coastal areas of Hawaii are reported. Samples were collected from the Kauai and Oahu shores (the Kahana and Maunalua Bay areas). Using atomic absorption spectroscopy mercury concentrations ranged from undetectable in 26 percent of the samples to a high of 1.0 ppM in one sample. The overall mean value was 0.08 ppM. Increases in mean mercury values with each elevation in trophic level indicated successive biological concentration and transport of mercury. (ND)

## RADIOACTIVE MATERIALS MONITORING AND TRANSPORT

*REFER ALSO TO CITATION(S) 5670, 5676, 5677, 5691, 5698, 5703, 5706*

**5706** (IDO—12080) **1975 progress report: Idaho National Engineering Laboratory site radioecology—ecology programs.** Markham, O.D. (Idaho National Engineering Lab., Idaho Falls (USA)). Jun 1976. 205p. Dep. NTIS $7.75.

Results are reported from measurements of the content of various radionuclides in the tissues of wild animals on or near the Idaho National Engineering Laboratory sampled during 1975. Tissue samples from antelope, waterfowl, rodents, rabbits, and doves were analyzed for 13 radionuclides, including $^{134}Cs$, $^{137}Cs$, $^{95}Zr$, $^{95}Nb$, $^{103}Ru$, $^{238}Pu$, $^{239}Pu$, $^{90}Sr$, $^{131}I$, and $^{60}Co$ which were responsible for the largest amounts of radioactivity. Measurements were also made of the content of $^{238}Pu$, $^{239}Pu$, and $^{241}Am$ in soil samples and the radioactivity in tumbling weeds at the radioactive waste management site. Data are included from studies on the ecology of the pygmy rabbit, Salvilagus idahoensis, amphibians, reptiles, birds of prey, rodents, and coyotes, and vegetation in relation to land use at the site. Seasonal variations in the deposition and retention of $^{141}Ce$ and $^{134}Cs$ on sagebrush and bottlebrush grass were compared. (CH)

**5707** (ORNL-tr—4210) **Release of radioactive materials from nuclear power plants. Report No. 2. Dispersion mechanisms, transport paths, and concentration factors for radionuclides in the cooling water recipient.** Rygg, B. (Norsk Institutt for Vannforskning, Oslo). 10 Jan 1974. Translation by A. Brynestad of NP—20251. 26p. Dep. NTIS $4.00.

The discharge of radioactive materials in the cooling water from a nuclear power plant may involve consequences for the interests involved in the recipient and its organisms. Of special interest is the transport of radionuclides in water, sediments, and organisms to man. The most important elements are H, Na, P, Cr, Mn, Fe, Co, Zn, Sr, Mo, Ru, I, Cs, and Ce. Metals with high affinity for organic material will be sorbed to sediments rich in organic material, while other elements will be enriched in algaes and arrive in the sediment through decay or excrement. Elements in particulate form will normally precipitate. Ions will generally not be enriched in sediments. Marine organisms may take up nuclides directly from the water and from food. The concentration factor is dependent on the chemical properties of the element and the physiology of the organism. The occurrence of elements in water and organisms in the Oslofjord district is poorly known and tables have therefore been derived from literature data to indicate the concentration factors to be expected. (NO)

### AQUATIC ECOSYSTEMS AND FOOD CHAINS

*REFER ALSO TO CITATION(S) 5698, 5703, 5707*

**5708** (ORNL/TM—4977) **COPEPOD4: a discrete time-delay model of COPEPOD population dynamics.** Maguire, L.A.; Blum, S.R.; Gehrs, C.W.; Van Winkle, W. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 109p. Dep. NTIS $5.50.

This report describes COPEPOD4, a time-delay model for copepod population dynamics. The model includes compartments representing numbers of subitaneous eggs, resting eggs, juveniles (nauplii and copepodids), and adults. Instar durations are represented using difference equations with constant time delays; thus, durations must be assumed constant. In the constant parameter version of COPEPOD4, clutch size and survival are also assumed constant. Events in the annual life cycle, such as resting egg production, are modeled as functions of season rather than as responses to environmental variables, such as water temperature or food. Parameter values were estimated from data gathered during a one-year field study of Diaptomus clavipes in a small pond in Oklahoma.

## THERMAL EFFLUENTS MONITORING AND TRANSPORT

*REFER ALSO TO CITATION(S) 5653*

**5709** (PB—242934) **Stability and mixing of a vertical round bouyant jet in shallow water. Final report.** Lee, J.H.; Jirka, G.H.; Harleman, D.R.F. (Massachusetts Inst. of Tech., Cambridge (USA). Energy Lab.). Nov 1974. 138p. (MIT-EL—74-014;195). NTIS $5.75.

Also available as Ralph M. Parsons Lab. Rept. No. 195.

Discharging heated water through submerged vertical round ports located at the bottom of a receiving water body is a currently used method of waste heat disposal. The prediction of the temperature reduction in the near field of the buoyant jet is a problem of environmental concern. The mechanics of a vertical axisymmetric buoyant jet in shallow water is theoretically and experimentally investigated. Four flow regimes with distinct hydrodynamic properties are discerned in the vicinity of the jet: the buoyant jet region, the surface impingement region, the internal hydraulic jump, and the stratified counterflow region. An analytical framework is formulated for each region. The coupling of the solutions of the four regions yields a prediction of the near field stability as well as the temperature reduction of the buoyant discharge. (GRA)

## SITE RESOURCE AND USE STUDIES

*REFER ALSO TO CITATION(S) 4447, 5680*

# ENVIRONMENTAL-SOCIAL ASPECTS OF ENERGY TECHNOLOGIES

## SOCIAL AND ECONOMIC STUDIES

*REFER ALSO TO CITATION(S) 4743, 5176, 5228, 5229, 5681*

**5710** (BNWL—2084) **Dynamic analysis of the environmental and social impacts of coal development in the eastern Powder River Basin of Wyoming, 1960—2010.** Jacobsen, J.J. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). Jul 1976. Contract E(45-1)-1830. 23p. Dep. NTIS $3.50.

A dynamic regional coal development model is constructed for the Eastern Powder River Basin of Wyoming. Using this model, alternative development schedules from a recent environmental impact statement submitted to the Department of the Interior are simulated. These alternatives include different mixes of export capacity, different coal conversion techniques within the region, as well as various levels of coal production. Exportation of 70 to 80 percent of an ultimate coal production of 180 million tons per year and the careful phasing of additional public services with population growth effectively reduce the social and environmental impacts of coal development. The alternative involving the addition of 43,000 megawatts of electrical generation capacity has very significant adverse social and environmental impacts on the region.

**5711** (COO—3531-11) **Technical progress report of biological research on the volcanic island, Surtsey, and environment for the year 1975.** Fridriksson, S. (Surtsey Research Society, Reykjavik (Iceland)). 1975. Contract E(11-1)-3531. 25p. Dep. NTIS $3.50.

The study involves terrestrial biological research on the volcanic island, Surtsey, off the coast of Iceland and the neighboring islands and environs of the Westman Islands, which are situated on the mid-Atlantic Ridge.

## ASSESSMENT OF ENERGY TECHNOLOGIES

*REFER ALSO TO CITATION(S) 5710*

## ENVIRONMENTAL IMPACT STATEMENTS

*REFER ALSO TO CITATION(S) 5595*

# BIOMEDICAL SCIENCES, BASIC STUDIES

## BEHAVIORAL BIOLOGY

*REFER ALSO TO CITATION(S) 5694*

## BIOCHEMISTRY

*REFER ALSO TO CITATION(S) 5716*

**5712** (CONF-760635—4) **Phospholipases as structural and functional probes for circulating lipoproteins.** Scanu, A.M. (Chicago Univ., Ill. (USA); Franklin McLean Memorial Research Inst., Chicago, Ill. (USA)). 1976. Contract E(11-1)-69. 15p. Dep. NTIS $3.50.

From Nobel symposium on nonlinear effects in plasmas; Lerum, Sweden (11 Jun 1976).

Studies have shown that enzymatic probes can be applied successfully to the study of the structure and function of circulating lipoproteins. Phospholipase $A_2$ permitted highly specific modifications in both low- and high-density lipoproteins, under mild reaction conditions, with no evidence of side reactions. Furthermore, it was possible by the use of this enzyme, to make precise kinetic analyses, and to characterize the substrate particles reisolated following enzymatic digestion. Studies have also shown that the hydrolyzable phospholipids, which are constituents of circulating lipoproteins, are a natural substrate for the enzyme—an observation which suggests that this reaction may have physiological importance in lipoprotein metabolism. The wealth of information derived from the current work ought to encourage precise kinetic analyses of other lipolytic enzymes known to cleave lipid constituents of circulating lipoproteins. The intensive work now being directed at the purification of these enzymes should make possible their use as structural probes to provide an understanding of their physiological role in fat metabolism.

**5713** **Properties and analysis of a stable derivative of pyrroline-5-carboxylic acid for use in metabolic studies.** Mezl, V.A.; Knox, W.E. *Anal. Biochem.*; **74**: No. 2, 430-440(Aug 1976).

The unstable metabolic intermediate $^1\Delta$-pyrroline-5-carboxylic acid (P5C or glutamic semialdehyde) cannot be isolated as a chemically pure solid because of its irreversible and concentration-dependent reaction with itself. This has been avoided by preparing it in dilute solution by periodate oxidation of DL-hydroxylysine and isolating it as a pure 2,4-dinitrophenylhydrazone from which P5C can be quantitatively regenerated. The product has been characterized by various chemical and enzymatic tests and by comparison with two other types of preparation of P5C. One of the reactions used to standardize it, reduction to proline by borohydride, also produced hydroxynorvaline in amounts indicating that an equilibrium exists between the ring and open forms of P5C and glutamic semialdehyde.

**5714** **Effects of luciferin concentration on the quantitative assay of ATP using crude luciferase preparations.** Karl, D.M.; Holm-Hansen, O. (Univ. of California, San Diego, La Jolla). *Anal. Biochem.*; **75**: No. 1, 100-112(Sep 1976).

The reaction kinetics of crude firefly lantern extracts with and without added synthetic luciferin were examined. The addition of exogenous luciferin to the reaction mixture resulted in an apparent increase in net light emission per unit of ATP in solution. This additional reactivity (up to 1000-fold) enables the detection of subpicogram levels of ATP. The effects of enzyme preparation, dilution, and aging procedures on the increased sensitivity of the ATP assay, as well as the assay limitations of the crude firefly lantern extracts, are also discussed.

## CYTOLOGY

**5715** (CONF-760315—5) **Cell synchronization in vivo: fact or fancy.** Dethlefsen, L.A.; Ohlsen, J.D.; Roti Roti, J.L. (Utah Univ., Salt Lake City (USA). Dept. of Radiology). 1976. Contract E(11-1)-2269. 42p. Dep. NTIS $4.00.

From 29. annual symposium on fundamental cancer research; Houston, Texas, United States of America (USA) (10 Mar 1976).

Increased host lethality was found when a second injection of HU was given at a 20 instead of a 24 hour interval. In this case the ability to predict an improved schedule is predicated on knowing when the tissue has recovered and thus can tolerate another insult. This is in contrast to an earlier injection wherein the tissue would be insulted in the midst of an acute cellular recovery process. We know of no satisfactory data which would justify establishing a clinical trial based only on the synchronization phenomena. New agents and/or techniques need to be developed before in vivo synchronization can be reasonably explored in a clinical context. In the meantime, much more laboratory data are needed on the recovery kinetics of normal and malignant tissues following insults with currently effective therapeutic agents. There is no doubt that correct scheduling based on the recovery kinetics of normal tissues can make available agents less toxic and potentially more effective. There is also no doubt that mathematical models for recovery kinetics will play a crucial role in the design of experiments for the testing of various hypotheses regarding the cellular effects of therapeutic agents.

## GENETICS

*REFER ALSO TO CITATION(S) 6419*

**5716** (CONF-760568—1) **Transcription and organization of yeast mitochondrial DNA.** Rabinowitz, M.; Jakovcic, S.; Martin, N.; Hendler, F.; Halbreich, A.; Lewin, A.; Morimoto, R. (Franklin McLean Memorial Research Inst., Chicago, Ill. (USA)). 1976. Contract E(11-1)-69. 12p. Dep. NTIS $3.50.

From International conference on the genetic function of mitochondrial DNA; Bari, Italy (24 May 1976).

Some topics discussed are as follows: restriction endonuclease mapping of mtDNA; analysis of the structure of mtDNA mutants; electron microscopy of yeast DNA; and mitochondrial RNA-DNA hybridization. It was shown that yeast mtDNA probably transcribe tRNAs for all amino acids and for several isoaccepting tRNA species, as well as messenger RNA for the three largest peptides of cytochrome oxidase. Data indicate that at least 50 to 60 percent of one mitochondrial genome is transcribed, and they suggest that symmetrical transcription may occur. (HLW)

**5717** (COO—3214-11) **Progress report on research on human genetics in Iceland, April 30th, 1976.** (Iceland Univ., Reykjavik). 1976. Contract E(11-1)-3214. 99p. Dep. NTIS $5.00.

A general demographic register, covering the Icelandic population from the year 1840 to present, is being compiled. This register is used to investigate the heredity of various genetic markers and the possible inheritance of disabilities and diseases. The register contains some 313,000 birth records, which are kept either on magnetic discs, punched cards, or on written forms. In addition to which the demographic data consists of the National Registry with birth numbers, marriage records, and death records with causes of death. All of these demographic registers are now so comprehensive that it is possible to use them as sources of data in various hereditary studies, despite the fact that there are still some individuals unlinked and certain minor errors, which need to be corrected.

**5718** (ORNL/TM—4976) **COPEPOD2: a Markov-type model for copepod population dynamics.** Maguire, L.A.; Gehrs, C.W.; Van Winkle, W. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-ENG-26. 97p. Dep. NTIS $5.50.

This report describes COPEPOD2, a model of copepod population dynamics derived from the Leslie matrix ad from Markov theory. The model consists of one compartment for each age-class within an instar, or group of instars. The number of compartments used for each instar corresponds to its duration in the life cycle. The model keeps track of the number of copepods in each compartment, using a one, one-half or one-quarter day time step. In a preliminary version of the model, population parameters—instar durations, mortality rates, clutch sizes—are assumed constant. Events in the annual life cycle are modeled as explicit functions of season, rather than as responses to environmental factors, such as water temperature and food. Parameter values used

were estimated from data gathered during a one-year field study of Diaptomus clavipes in a small pond in Oklahoma.

## METABOLISM

*REFER ALSO TO CITATION(S) 5762*

**5719** (COO—2538-20) **Photorespiration in marine phytoplankton.** Morris, I.; Beardall, J. (Northeastern Research Foundation, Inc., West Boothbay Harbor, Maine (USA). Bigelow Lab. for Ocean Studies; University Coll., London (UK)). 1975. Contract E(11-1)-2538. 9p. Dep. NTIS $3.50.

In recent years the phenomenon of photorespiration (a light stimulated respiration in photosynthetic organisms) has attracted considerable interest among higher plant physiologists. The biochemistry of this phenomenon is different from that of the normal dark respiration and the existence of photorespiration is an indication of important characteristics of the photosynthetic mechanism. Little is known of photorespiration among marine phytoplankton. This paper reports the results of studies with the marine diatom Phaeodactylum tricornutum. Two pieces of evidence suggest that photorespiration exists in this alga; the oxygen inhibition of photosynthesis, particularly at low carbon dioxide concentrations and the presence of a ribulose diphosphate dependent oxygenase activity in cell-free extracts. This paper will discuss the possible significance of these observations to the photosynthetic efficiency of marine phytoplankton.

**5720** (UR—3490-946) **Calcium transport in the intestine.** Halloran, B.P. (Rochester Univ., N.Y. (USA). Dept. of Radiation Biology and Biophysics). 1976. Contract E(11-1)-3490. 200p. Dep. NTIS $7.50.

Thesis.

The effects of colchicine and cytochalasin B (CB) on the ultrastructure, calcium distribution and transport characteristics of the intestine were investigated. Colchicine at low doses inhibited both cellular uptake and transepithelial transport of calcium. At high doses uptake and transport were enhanced. Neither of these effects were dependent on the disruption of microtubules. CB reduced calcium uptake and translocation to the blood but only at relatively high concentrations (greater than 25 μg/ml). CB treatment (50 μg/ml) did not disrupt the brush border microfilaments, but rather induced the formation of large vacuoles within the tissue. The site of action of colchicine and CB appears to be at the brush border membrane, and does not appear to involve either microtubules or microfilaments. Both colchicine and CB had a limited effect on the cellular distribution of calcium. A coordinated electron probe-electron microscope study of the intestinal epithelium indicated that relatively high concentrations of calcium were associated with the rough endoplasmic reticulum (and possibly mitochondria), and areas of mucin accumulation in goblet cells. The size of the absorptive cell localizations and their lack of association with any discernable cell structure led to a re-evaluation of the oxalate precipitation technique for the maintenance of intracellular calcium and to the development of a new preparative method, independent of any exogenous precipitating agent. The new method is based on freeze drying and is shown to preserve the in vivo distribution of Na, K, P and Ca. The calcium distribution using this technique was found to involve higher concentrations of cytoplasmic calcium, but considerably fewer and much smaller localizations than found with the oxalate technique.

### TRACER TECHNIQUES

**5721** (ORNL/CSD—4) **Experimentally based systems-theoretic approach to the study of metabolism. II. Parameter identification.** Kretchmar, A.L.; Price, E.J.; Heidel, J.W.; Serbin, S.M. (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 28p. Dep. NTIS $4.00.

A concrete model for intermediary metabolism is analyzed mathematically and numerically with the use of input-output data. Parameters are determined and modifications of the original model are discussed. Respiration response data are analyzed from mice following injections of $^{14}C$-labeled serine, formate, and glycine. (HLW)

## MEDICINE

*REFER ALSO TO CITATION(S) 5606*

### TRACER TECHNIQUES

**5722** (COO—3173-16) **Pathophysiologic effects of stable iodine used as a thyroidal blocking agent to reduce thyroid radiation exposure. Progress report, November 1, 1975—October 31, 1976.** Becker, D.V.; Hurley, J.R. (Cornell Univ., New York (USA). Dept. of Medicine). 1976. Contract E(11-1)-3173. 8p. Dep. NTIS $3.50.

In an effort to determine whether iodide administration in man can induce injury to thyroid follicular cells similar to that demonstrated in lower animals, this study measures thyroglobulin, thyroxine and triiodothyronine and thyroid autoantibodies in the serum before and after administration of iodine in a variety of patients. In the last eight months primary efforts have been devoted to the development of a high specificity and sensitivity radioimmunoassay of thyroglobulin and its preliminary clinical application. Human thyroglobulin obtained from operative specimens was purified and its identity and purity established. Rabbits were injected with thyroglobulin for 30 weeks with the appearance of significant titres of antibodies within 6 weeks. The antibody developed was examined for immunological purity and used in a radioimmunoassay system with thyroglobulin labeled in this Laboratory with $^{125}I$.

## MORPHOLOGY

**5723** **New Clitocybe from the Alaskan Arctic.** Laursen, G.A. (Virginia Polytechnic Inst. and State Univ., Blacksburg); Miller, O.K. Jr.; Bigelow, H.E. *Can. J. Bot.*; 54: No. 9, 976-980(1 May 1976).

A new species of Clitocybe is described from the Alaskan Arctic. This agaric grows on low-center polygon rims, high-center polygons, and on beach ridges. Drawings of microscopic features and macrophotographs are included.

## PHYSIOLOGICAL SYSTEMS

**5724** (UR—3490-952) **Effects of localized microwave exposure on the dog thyroid.** Magin, R.L. (Rochester Univ., N.Y. (USA)). 1976. Contract E(11-1)-3490. 164p. Dep. NTIS $6.75.

Thesis.

The effects of localized microwave (2.45 GHz, CW) exposure of the dog thyroid gland were investigated. A dielectrically loaded waveguide applicator was designed and fabricated which efficiency couples microwave energy to a small (2.54 cm x 5.08 cm) area of biological tissue. The function of the thyroid gland was assessed by the measurement of total plasma thyroxine (T4) using a radioimmunoassay.

## PUBLIC HEALTH

*REFER ALSO TO CITATION(S) 5764*

# BIOMEDICAL SCIENCES, APPLIED STUDIES

## RADIATION EFFECTS

**5725** **Radiation research. Biomedical, chemical, and physical perspectives. Proceedings of the fifth international congress, Seattle, Washington, July 14—20, 1974.** Nygaard, O.F.; Adler, H.I.; Sinclair, W.K. (eds.). New York; Academic Press, Inc. (1975). 1399p. (CONF-740715—).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

Separate abstracts were prepared for 101 of the 115 papers presented in this symposium. The other 14 papers include introductory material and a variety of nonnuclear biomedical papers. (ERB)

## RADIATION EFFECTS ON BIOCHEMICALS

### IN VITRO

**5726** **Protection by AET against inactivation of transforming DNA by near-ultraviolet light: action spectrum.** Peak, M.J.; Peak, J.G. (Argonne National Lab., Ill. (USA)). *Photochem. Photobiol.*; 22: No. 3;4, 147-148(Sep 1975).

Research note.

**5727 Radiolysis of aqueous solutions of difluorochloromethane.** Salih, I.M.; Soylemez, T.; Balkas, T.I. (Middle East Technical Univ., Ankara). *Radiat. Res.*; 67: No. 2, 235-243(Aug 1976).

Results of γ-radiolysis experiments with deaerated aqueous solutions of difluorochloromethane have shown that the initial reaction occurs via the attack of hydrated electron on this solute, to produce chloride ions and difluoromethyl radicals. A rate constant of 2.9 +- 0.8 x $10^9$ $M^{-1}$ $sec^{-1}$ was measured for the hydrated electron reaction. It has been found that difluoromethyl radicals undergo secondary dimerization and hydrolysis reactions. The product of the dimerization reaction has been identified as tetrafluoroethane, whereas the hydrolysis reaction leads to the formation of carbon dioxide and fluoride ions. A dose-rate dependence has been observed for the products of secondary radical reactions.

## RADIATION EFFECTS ON CELLS

### EXTERNAL SOURCE

*REFER ALSO TO CITATION(S) 5743, 5746*

**5728** (COO—3243-5) **Annual report on research project, October 1, 1975—September 30, 1976.** Rossi, H.H. (Columbia Univ., New York (USA). Radiological Research Lab.). 1976. Contract E(11-1)-3243. 394p. Dep. NTIS $10.75.

Progress is reported on radiobiological studies at the cellular level with emphasis on the effects of cyclotron-produced neutrons and heavy ions and microdosimetry. A list is included of some 50 publications during the period covered that report the results of the studies in detail. (CH)

**5729** (AEC-tr—7533/9, pp 58-65) **Cell cycle disturbances in slowly growing sublines isolated from x-irradiated L5178Y-S cell populations.** Beer, J.Z.; Bocian, E.; Budzicka, E.; Szumiel, I.; Ziemba-Zak, B.; Kopec, M. (Inst. of Nuclear Research, Warsaw). Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

Cell cycle was analyzed autoradiographically in a control line of murine leukemic lymphoblasts L5178Y-S and in two slowly growing sublines isolated from cell cultures irradiated with 300 rads of x rays. It was found that prolongation of the cell cycle in the slowly growing sublines is connected primarily with delayed progression through G2 phase. This conclusion was further supported by results of determination of DNA content per cell in 13 slowly growing cell sublines and karyotype analysis of 18 sublines. No correlation was found between a subline's mean doubling time and its chromosome number whereas DNA content per cell was clearly dependent on the growth rate.

## RADIATION EFFECTS ON MICROORGANISMS

### BASIC STUDIES

*REFER ALSO TO CITATION(S) 5749*

### FOOD PRESERVATION

**5730 Use of ionizing radiation for preservation of food and feed products.** Josephson, E.S.; Brynjolfsson, A.; Wierbicki, E. (Army Natick Labs., MA). pp 96-117 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

Exposing food to ionizing radiation can contribute to closing the worldwide food deficit by reducing food spoilage losses, by making available more food of higher nutritional quality (animal protein food) to more people, and by keeping prices down by reducing losses. Because ionizing radiation kills disease-causing organisms, it can reduce the incidence of food-borne diseases. It also reduces our dependence upon some of the chemical additives, such as nitrites and nitrates, now being questioned by health authorities to control food spoilage and food-borne diseases. The three basic types of ionizing radiation used for processing of food are electrons (10 MeV maximum energy), X-rays (5 MeV maximum energy) produced by electrons in an X-ray target, and gamma rays from $^{60}Co$ and $^{137}Cs$. Electrons, X-rays, and gamma rays cause ionization in the food by either the primary electrons or by the secondary electrons resulting from gamma or X-ray interactions in the food with little rise in temperature and little total chemical change. The ionized and activated molecules form unstable secondary products that kill the organisms. Another effect is to slow down post-harvest growth and maturation in some fruits and vegetables.

### RADIOSTERILIZATION OF MEDICAL SUPPLIES

**5731 Radiation sterilization: an industrial process.** Ley, F.J. (Irradiated Products Ltd., Wiltshire, Eng.). pp 118-130 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

A new dimension has been added to the use of radiation in the medical field with the introduction of radiation as a sterilizing agent. Its use in diagnosis through radioactive tracers or X-rays and in therapy administered with the most sophisticated of electrical machines or radioisotope units, is familiar in the hospital world, being well established therein. In contrast, the application of radiation sterilization is in industry where the installation of large radiation sources is already commonplace in many countries. The beginnings in the early 1950's centered on the Van de Graaff machine and linear accelerators and the pioneering efforts of Ethicon Inc. here in the United States must be recognized. However, although sterilization with electron beams is still current practice in a number of plants, the use of gamma rays from cobalt-60 is preferred. The first steps in this direction were taken by the U.K.A.E.A. which, in common with similar organizations elsewhere, was attempting to exploit the tremendous potential for cobalt-60 production arising through the rapid construction of nuclear reactors. The first full-scale commercial gamma plant was commissioned in the U.K. in 1960. It reached a loading of 500,000 curies before its demolition after twelve years of operation. The process gained rapid acceptance within industry and approval by health authorities because it provided a "cold" sterilization method combining the property of lethal effect with penetration. Its immediate impact occurred in the introduction of disposable products making it possible, for example, to use heat-labile plastics and new packaging materials and package designs. Certainly, the technique has proved complementary to sterilization methods based on heat and to the use of chemical agents, in particular ethylene oxide gas.

## RADIATION EFFECTS ON PLANTS

### BASIC STUDIES

**5732 Mutations in plant breeding: a glance back and a look forward.** Gustafsson, A. (Univ. of Lund, Sweden). pp 80-95 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

This brief retrospect of previous shortcomings and procedures really indicates the need for a better co-ordination and co-operation in plant breeding. We now know which mutagens are essential in practical mutation work, and we include radiations as well as chemicals. We now know that there is no principal difference between natural and induced variation. We can easily induce mutational events covering the gap between gross chromosomal rearrangements and DNA-base substitutions. We also know that induced variation may in the future fill and replace the loss of natural variability, or may even extend the limits of variation. We know that mutation and recombination—as evidenced, for instance, by the successful work in barley—will be united into routine procedures, also leading to new breakthroughs in plant improvement. Moreover, ingenious techniques of mass testing are under way, combining traditional and prospective ideas. The mutation method has come to stay, not alone but with gene recombination, with heterosis and with polyploidy. We say that the present is the past's future. To glance back is then to look forward; failures give rise to progress. A synthesis of breeding methods is around the corner.

## RADIATION EFFECTS ON ANIMALS

### MAN

*REFER ALSO TO CITATION(S) 5690, 5755, 5765*

**5733** (AD-A—012703) **Research on human skin laser damage thresholds. Final report, Nov 1971—Jun 1974.** Rockwell, R.J. Jr.; Goldman, L. (Cincinnati Univ., Ohio (USA). Dept. of Dermatology and Laser Labs.). Jun 1974. Contract F41609-72-C-0007. 160p. (DERM-LL—74-1003). NTIS $6.25.

The report gives the results of a two-year study to determine the lowest radiant exposure levels at which the first observable reactions occur on human skin exposed to electromagnetic radiations emitted by normal mode and Q-switched ruby, Q-switched neodymium-glass, carbon dioxide, argon and neodymium-YAG laser devices. The principal goal of the study was to establish the 50 percent probability dose for such minimal reactions observed one-hour post-exposure. Such minimal radiant exposure levels are defined, for the purpose of this report, as the fifty percent probability dose for minimal reactions, and are designated as MRD50 (Minimal Reaction Dose, 50% probability). (GRA)

**5734** (BNWL-SA—5644) **Personnel protection aspects of x-ray diffraction apparatus.** Waite, D.A.; McClelland, T.W.; Bramson, P.E. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). 15 Apr 1976. Contract E(45-1)-1830. 13p. (CONF-760525—2). Dep. NTIS $3.50.

From American industrial hygiene conference; Atlanta, Georgia, United States of America (USA) (16 May 1976).

The objective of radiation safety is to keep radiation exposure of man to an acceptable level without imposing undue restriction upon the use of radiation concerned. Meeting this objective may involve many considerations. This discussion will attempt to outline, from a health physics viewpoint, considerations in radiation safety in using x-ray diffraction equipment. Important considerations in keeping exposures to a practicable minimum may be categorized into several general groups including: equipment and facility configurations; equipment operational characteristics; radiological evaluation; and operator training.

**5735** (ORNL—5191) **CHORD simulation for insult assessment to the red bone marrow.** Jones, T.D. (Oak Ridge National Lab., Tenn. (USA)). Sep 1976. Contract W-7405-eng-26. 37p. Dep. NTIS $4.00.

Critical Human Organ Radiation Dosimetry (CHORD) probability density functions for A-P, P-A, bilateral, rotational, and isotropic incidence, plus simple depth-dose data, permit the rapid estimation of the radiation insult to the active red bone marrow system of the ICRP Reference Man. The CHORD concept follows the variations in the microscopic processes of absorption, attenuation, and scattering on a macroscopic level so that it is not necessary to attempt detailed calculations for each and every case of interest. Similar techniques have been applied to reactor criticality calculations and the general logic of the CHORD process can be applied to any cause-response type situation which can be described in terms of variation with distance in the medium of interest. Doses to active bone marrow from exposures to photons and neutrons are presented and excellent agreement is shown with the few available experimental results.

**5736** **Late effects of acute external exposure to ionizing radiation in man.** Jablon, S. (National Research Council, Washington, DC). pp 132-145 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

The late effects of acute external exposure to ionizing radiation in man are discussed. Included among the late effects are nonneoplastic mortalities and mortalities due to cancer including leukemia. The hazards of prenatal irradiation are considered. (ERB)

**5737** **Chemical and radiation carcinogenesis in man and experimental animals.** Miller, J.A.; Miller, E.C. (Univ. of Wisconsin, Madison). pp 158-168 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

It is now well established that some cancer in man results from exposures to certain chemicals and radiations, both ultraviolet and ionizing radiations. These chemical and physical agents are also carcinogenic in experimental animals and, where adequately tested, in mammalian cell cultures. However, only very limited data are available on the relative roles of and the interrelationships, if any, between these various environmental agents in the causation of the majority of the cancers in man. Nothing is known of the relationship between these agents and possible carcinogenic viral information in the etiology of cancer in man. Furthermore, little is known about the molecular mechanisms by which chemicals and radiations induce cancers in either man or experimental animals. The objective of this brief review is to present certain aspects of chemical and radiation carcinogenesis in man and experimental animals and some of the problems in the elucidation of their roles in carinogenesis in the human.

**5738** **Multiple simultaneous event model for radiation carcinogenesis.** Baum, J.W. (Brookhaven National Lab., Upton, N.Y. (USA)). *Health Phys.*; **30**: No. 1, 85-90(Jan 1976).

A mathematical model is proposed which postulates that cancer induction is a multi-event process, that these events occur naturally, usually one at a time in any cell, and that radiation frequently causes two of these events to occur simultaneously. Microdosimetric considerations dictate that for high LET radiations the simultaneous events are associated with a single particle or track. The model predicts: (a) linear dose-effect relations for early times after irradiation with small doses, (b) approximate power functions of dose (i.e. Dsup(x)) having exponent less than one for populations of mixed age examined at short times after irradiation with small doses, (c) saturation of effect at either long times after irradiation with small doses or for all times after irradiation with large doses, and (d) a net increase in incidence which is dependent on age of observation but independent of age at irradiation. Data of Vogel, for neutron induced mammary tumors in rats, are used to illustrate the validity of the formulation. This model provides a quantitative framework to explain several unexpected results obtained by Vogel. It also provides a logical framework to explain the dose-effect relations observed in the Japanese survivors of the atomic bombs.

**5739** **Simplified RBE-dose calculations for mixed radiation fields.** Katz, R.; Fullerton, B.G. Jr.; Roth, R.A.; Sharma, S.C. (Nebraska Univ., Lincoln (USA)). *Health Phys.*; **30**: No. 1, 148-150(Jan 1976).

Brief note.

**5740** **Radiation doses from iodine-129 in the environment.** Soldat, J.K. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)). *Health Phys.*; **30**: No. 1, 61-70(Jan 1976).

Recently, renewed attention has been drawn to $^{129}I$, a radionuclide which, because of its long half-life ($1.6 \times 10^7$ yr), has a potential for long-term accumulation in the environment from low level chronic releases at nuclear facilities. The transfer of $^{129}I$ through the biosphere and the resultant radiation doses to man are discussed. Metabolic parameters are tabulated for four ages; 1, 4, 14 and adult. These parameters include fractional uptake via inhalation and ingestion, breathing rate, mass, radius and iodine content of the thyroid, and the energy absorbed per disintegration of $^{129}I$ vs thyroid size. Factors are presented for calculation of doses from intake or concentration of $^{129}I$ in the thyroid. Factors are also derived for estimating thyroid doses from $^{129}I$ air concentration via the inhalation, leafy vegetable, milk or meat pathways. Analysis of the atom ratios of $^{129}I$:$^{127}I$ in the thyroid required to yield a dose rate of 1500 mrem/yr reveals that on this basis the adult thyroid reaches the limiting dose rate at a ratio of 1:48 (3.6 $\mu$Ci $^{129}I$/g iodine). However, a higher ratio of 1:11 (15 $\mu$Ci/g I) is required for the infant thyroid to receive the same dose rate. The reason for this difference is the higher stable iodine concentration in the adult thyroid (350 ppm) than in the infant thyroid (90 ppm). In all instances, however, a dose rate of 1500 mrem/yr would result from a concentration of $1.3 \times 10^{-3}$ $\mu$Ci $^{129}I$/g of thyroid.

### VERTEBRATES

*REFER ALSO TO CITATION(S) 5737*

**5741** (AD-A—012684) **The calculation of absorbed dose and tissue transmission factors. Technical memo.** Warshawsky, A.S. (Army Nuclear Agency, Fort Bliss, Tex. (USA)). 11 Nov 1974. 19p. (NUA-TM—1-74). NTIS $3.25.

Contents: Interaction between radiation and tissue; Radiation quantities and units; Radiation quality and dose equivalent; History of dose calculations; Tissue transmission factors; Results and limitations. (GRA)

**5742** (AD-A—014065/7ST) **Correlation of animal, crypt, and stem cell survival in fission neutron irradiated mice: a chemical protection study. Final report, Oct 1971—Dec 1974.** Sigdestad, C.P. (Louisville Univ., Ky. (USA). School of Medicine). 1 Feb 1975. Contract DADA17-72-C-2038. 101p. NTIS $5.25.

The report surveys the effectiveness of newly synthesized antiradiation compounds (WR-2721, WR-77913, WR-638, WR-1607, WR-2347, WR-3689, WR-109342, WR-2822, and WR-2823) in comparison with the other protectors (MEA and AET). The effects of high energy x-rays (4 MeV) and fission neutrons was tested on (1) intestinal crypt survival, (2) lethality, LD50 and (3) total and per crypt cellularity. (GRA)

**5743** (COO—2269-11) **Kinetic and biochemical studies on tumor growth. Final report, October 1, 1967—July 14, 1976.** Dethlefsen, L.A. (Utah Univ., Salt Lake City (USA). Dept. of Radiology). Contract AT(11-1)-2269. 10p. Dep. NTIS $3.50.

The normal growth kinetics and the recovery kinetics following therapeutic perturbations with drugs and x-irradiation for the mouse duodenal crypt cells and the S102F and slow line tumor cells have been studied in depth, the rationale being that a detailed understanding of these phenomena would enhance our knowledge about tumor biology per se and also expand our appreciation of how normal and malignant tissues respond to and recover from therapeutic insults. Hopefully, such knowledge will eventually allow one to design logical, optimal protocols for cancer therapy. During the course of this contract, a new direct method (The $^{125}$I-IUdR Method) for measuring cell loss from solid tumors in vivo was developed. Also it was established that the new flow cytometry methodology would be very useful for studying the normal and perturbed kinetics of solid tumors. The extensive hydroxyurea data as well as the preliminary adriamycin and x-irradiation data which have been collected on the recovery kinetics of the duodenum and mammary tumors have advanced our awareness of the complexity of these phenomena and how different the effects are when different drugs are used either alone or in conjunction with x-irradiation.

**5744** (COO—3017-25) **Radiation carcinogenesis. Progress report III, 15 March 1975—15 March 1976.** Warren, S.; Gates, O. (New England Deaconess Hospital, Boston, Mass. (USA)). Mar 1976. Contract E(11-1)-3017. 17p. Dep. NTIS $3.50.

The attention of forensic pathologists has been drawn to the criteria essential for the recognition of radiation death or injury in the hope that such cases will be better recognized and that some false claims of radiation damage might be prevented at the local level. The results of experiments on parabiont rats, one of which had been irradiated with 1000 R of 250 kVp x-ray, the other shielded, are reviewed. With controls and related special studies the total is over 3000 pairs equally divided as to sex. Much information on the relative sensitivity of different tissues and organs to tumor induction is available and is being statistically analyzed. These experiments have provided further evidence of the effectiveness of parabiosis in assuring survival after 1000 R x-radiation and have enabled us to learn of the types of problems that might be expected in the way of late effects in heavily irradiated individuals should they be enabled by effective therapy to survive the acute phases of the radiation syndrome. Additional evidence has been brought out that carcinogenesis in some hormonally dependent tissues and organs is not so much a direct effect of radiation as it is a summation of this effect and of alterations caused by changes in hormonal balance brought about by the radiation.

**5745** (COO—3017-26) **Radiation carcinogenesis. Comprehensive three-year progress report, 1 May 1972—15 March 1976.** Warren, S.; Gates, O. (New England Deaconess Hospital, Boston, Mass. (USA)). Mar 1976. Contract E(11-1)-3017. 19p. Dep. NTIS $3.50.

Progress is reported on studies on the pathological effects of various doses of x radiation on rats and mice, with emphasis on radioinduced carcinogenesis in parabiont rats with one of the pair exposed to 1000 R of whole body x radiation and the other shielded. Results are included from studies on alterations in metabolic parameters and life span induced by irradiation. (CH)

**5746** (AEC-tr—7533/9, pp 66-71) **Evaluation of absorbed dose of gamma and x-ray radiation using bone tissue as a dosimeter.** Stachowicz, W. (Inst. of Nuclear Research, Warsaw); Michalik, J.; Dziedzic-Goclawska, A.; Ostrowski, K. Oct 1974. Translated from Nukleonika; 19: No. 9, 1974.

In Nukleonika.

The dose dependence curves were obtained showing the relation between the number of stable radiation-induced paramagnetic centers and radiation dose in the range of 100 to 20,000 rads for $^{60}$Co source and 250 kV rtg apparatus. Differences in slopes of both curves are interpreted in terms of differences in the values of stopping power. The possibility to use skeletal tissues as dosimeter for absorbed doses in the range beginning at 10 rads is discussed.

**5747 Suppression and recovery of the immune response and CFU potential of mice during and after chronic low-dose-rate gamma-irradiation.** Huebner, K.F.; Gengozian, N.; Gilman, T.A. (Oak Ridge Associated Universities, Inc., Tenn. (USA). Medical Div.). *Int. J. Radiat. Biol.;* **28**: No. 4, 301-312(Oct 1975).

Chronic exposure of mice to $^{60}$Co γ-rays at rates of 1.6 R/hr and 6 R/hr led to profound immunosuppression, as demonstrated with the Jerne haemolysis-in-agar technique. The immunosuppressive effect was dose-rate dependent. Thus, significant reduction of the number of splenic antibody plaque-forming cells (PFC) to sheep red blood cells was seen after exposure to 1005 R at 1.6 R/hr; at the higher exposure rate of 6 R/hr, PFC suppression was seen after a total dose of only 468 R. Although recovery of the PFC response was possible after accumulated doses of 1005, 1579, and 2138 T at 6 R/hr and 5256 R at 1.6 R/hr, normal immunological capacity had not returned 120 days after irradiation. In contrast the recovery of splenic colony-forming units (CFU), as an expression of the haematological potential of chronically irradiated mice was found to be much more rapid than the repair of the immune system. Thus, 10 days after irradiation, at a time when little or no recovery in immune competence was apparent, the spleen of the chronically irradiated animal had a CFU capacity about 50 times greater than has that of a normal, unirradiated mouse. The CFU's in the chronically irradiated spleens were also shown to be functional by virtue of their ability to protect lethally irradiated animals from haemopoietic death.

**5748 Tolerance of the spinal cord of rats to irradiation with neon ions.** Leith, J.T. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.); Woodruff, K.H.; Lewinsky, B.S.; Lyman, J.T.; Tobias, C.A. *Int. J. Radiat. Biol.;* **28**: No. 4, 393-398(Oct 1975).

Letter to the editor.

### BASIC STUDIES

**5749 Problems in the reevaluation of genetic risks from radiation and other environmental hazards.** Oftedal, P. (Univ. of Oslo). pp 169-181 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

Genetic risks from radiation are evaluated using data on Drosophila and Saccharomyces. The response modifying effects of certain chemicals such as caffeine are also discussed. (ERB)

**5750 Effects of chronic gamma radiation on the growth and survival of juvenile clams (Mercenaria mercenaria) and scallops (Argopecten irradians).** Baptist, J.P.; Wolfe, D.A.; Colby, D.R. (National Marine Fisheries Service, Beaufort, N.C. (USA). Center for Estuarine and Menhaden Research). *Health Phys.;* **30**: No. 1, 79-83(Jan 1976).

Juvenile clams (Mercenaria mercenaria) and scallops (Argopecten irradians) from North Carolina were exposed to five intensities of chronic γ radiation for 3 to 14 months during 1973/1974. Exposure rates ranged downward from 37 rads/hr to levels slightly higher than background radiation. Deleterious effects on growth and survival of clams occurred only at the highest exposure rate (37 to 16 rads/hr). Clams exposed to low radiation levels (0.007 to 0.008 rads/hr) increased in weight, but not in length, faster than the controls. One-half of the clams exposed to the highest radiation level survived to 159 days, after a cumulative dose of 132 krads, and only 10 % survived to 14 months after a cumulative dose of 150 to 346 krads. No deleterious effects on growth and survival of scallops were apparent during 84 days of exposure to a cumulative radiation dose of 71.7 krads.

## RADIONUCLIDE EFFECTS - INTERNAL SOURCE

### MAN

*REFER ALSO TO CITATION(S) 5689, 5765*

**5751 Risk of malignancy from internally-deposited radioisotopes.** Rowland, R.E. (Argonne National Lab., IL). pp 146-155 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

The somatic effects of the internal emitters is considered. The shape of the dose-response function is deduced from the data itself. It is concluded that the major long-term somatic effect of radiation on man is cancer. Much of the data used in the study is taken from radium studies.

**5752 · Standard field methods for determining $^{137}Cs$ and $^{131}I$ in vivo.** Palmer, H.E. (Battelle Pacific Northwest Labs., Richland, Wash. (USA)); Branson, B.M.; Cohn, S.H.; Dean, P.N.; Eckart, J.A.; Lloyd, R.D.; Miller, C.E. *Health Phys.*; 30: No. 1, 113-118(Jan 1976).

Methods have been developed for measuring the body content of $^{137}Cs$ and the thyroid content of $^{131}I$ using rather simple, compact equipment. Procedures for calibrating the equipment were designed to provide reproducible results with a variety of counting equipment and environmental conditions. The methods and calibrations were tested by interlaboratory comparison among seven laboratories throughout the U.S. These methods should find application for measuring $^{137}Cs$ and $^{131}I$ in those people who do not have access to an established whole-body counting facility.

### ANIMALS

*REFER ALSO TO CITATION(S) 5689, 5722, 5757*

**5753 $^{90}Sr$-$^{90}Y$ dose distribution in beagles: injection relative to ingestion.** Momeni, M.H.; Jow, N.; Bradley, E. (California Univ., Davis (USA). Radiobiology Lab.). *Health Phys.*; 30: No. 1, 3-19(Jan 1976).

The $^{90}Sr$ body burden ingested as a constant fraction of dietary calcium in 1.5 yr $^{90}Sr$-$^{90}Y$ feeding was analyzed for uptake and retention. Retention times were compared to that for a single intravenous injection of $^{90}Sr$ at $t_0$ 1.5 yr of age. The uptake parameters were compared with skeletal and body growth rates. No significant differences in body weight pattern of 452 beagles were observed between the controls and $^{90}Sr$-fed dogs. The retention parameters in the singly injected beagles were compared with those for $^{90}Sr$ inhalation studies; no difference was observed. The average skeletal dose rate and the time-integrated dose were calculated from the mean body burden as a function of age and skeletal/body weight ratios. The local dose rates and dose were compared to the average skeletal dose and dose rate. The local dose to marrow at the proximal humerus was always overestimated by the average skeletal dose and dose rate. The local dose rate overestimated the dose to hematopoietic tissue for the first 5 yr of life partially due to averaging of the higher $^{90}Sr$ concentration in cortical bone with the lower concentration in trabecular bones. Autoradiographic and local measurement of $^{90}Sr$ in bone revealed that a uniformly labeled skeleton (constant $^{90}Sr$/g of ash) was obtained in 1.5 yr of $^{90}Sr$ feeding. For periods $t > t_0$ the fast local turnover at the proximal region relative to cortical bone produced cold spotsand low activity regions of cancellous bone. In contrast, the injected cortical bones showed hot spot areas on a diffuse background.

**5754 Local dosimetry and qualitative changes in $^{226}Ra$- and $^{90}Sr$-$^{90}Y$-labeled beagle humeri.** Momeni, M.H.; Williams, R.J.R.; Fisher, G.L.; Rosenblatt, L.S. (California Univ., Davis (USA). Radiobiology Lab.). *Health Phys.*; 30: No. 1, 21-34(Jan 1976).

Changes in $^{226}Ra$- or $^{90}Sr$-$^{90}Y$-labeled beagle humeri were measured radiographically and by a photon absorptiometric density technique. Quantitative autoradiography and local dose measured by thermoluminescent dosimetry were compared with the average regional dose. Radium-226-labeled humeri manifested bone damage for levels as low as 8 ng/kg of body weight corresponding to a time-integrated dose of 300 rad by 10 yr of age. Whereas, $^{90}Sr$-labeled humeri manifested bone damage for dose levels of about 4 $\mu$Ci $^{90}Sr$-$^{90}Y$ or more average daily ingestion from midgestion to 18 months of age. These dogs accumulated a dose in excess of 7 krad by 10 yr of age. Thus, based on average time-integrated dose, a factor of 23-times more dose of $^{90}Sr$-$^{90}Y$ relative to $^{226}Ra$ is required to induce a radiographically detectable skeletal change by 10 yr of age.

## NUCLIDE KINETICS AND TOXICOLOGY

### MAN

**5755 Quantitative analysis of the fate in man of $^{37}Ar$ produced in body calcium by fast neutron exposure.** Bigler, R.E.; Laughlin, J.S. (Memorial Sloan—Kettering Cancer Center, New York). *Radiat. Res.*; 67: No. 2, 266-276(Aug 1976).

Methods have been developed to investigate the quantitative production and the ultimate fate of $^{37}Ar$ produced in bone calcium in the living human body. A healthy male subject's whole body was irradiated using cyclotron-produced neutrons provided by the $^{9}Be(^{3}He,n)$ reaction. The dose of fast neutrons was limited to 1.6 mrad. Six breath samples were collected and assayed for $^{37}Ar$ content over a 12.5 hr period after irradiation. Low background (0.5 to 5 counts/day) gas proportional counting techniques were used to assay samples containing as little activity as 0.01 dis/min corrected to end of irradiation. Analysis of the exhalation data by a two-component exponential relation indicated 82 percent of the activity left the body by way of the lungs with a half-time of 40 min. The remaining 18 percent was exhaled with a 200 min half-time. Exhalation was demonstrated to account for approximately 70 percent of the $^{37}Ar$ activity produced in the body. Evidence from studies of isolated bone indicated that essentially permanent trapping in bone crystals accounted for the remaining activity.

### ANIMALS

*REFER ALSO TO CITATION(S) 5689, 5753*

**5756 (SRO—641-22) Radioactive tracer studies of soil and litter arthropod food chains. Progress report, November 1, 1975—October 31, 1976.** Crossley, D.A. Jr. (Georgia Univ., Athens (USA). Dept. of Entomology). 31 Jul 1976. Contract E(38-1)-641. 41p. Dep. NTIS $4.00.

Progress is described in radioisotope measurement of nutrient element flow in soil-litter arthropod food chains. Two models of accumulation (Goldstein-Elwood, Reichle-Crossley) were tested experimentally and found to yield equivalent predictions of $^{134}Cs$ and $^{85}Sr$ movement through arthropod populations. Radioisotope retention studies were used to compare trophic strategies of soil tipulids from arctic tundra and temperate forest. Arctic tipulids were found to compensate for low temperatures with enhanced assimilation and slower turnover of nutrients. Electron microprobe analysis is being used to measure elemental content of soil microarthropods. Concentrations as high as 70,000 ppm of Ca are reported for oribatid mites. Improved measurements of input-output nutrient concentrations are reported for island ecosystems on granitic outcrops, which are being subjected to experimental alteration in studies of ecosystem function.

**5757 $^{144}Ce$ in tissue of beagle dogs after inhalation of $CeCl_3$ with special emphasis on endocrine glands and reproductive organs.** Cuddihy, R.G.; Boecker, B.B.; McClellan, R.O.; Kanapilly, G.M. (Lovelace Foundation for Medical Education and Research, Albuquerque, N.Mex. (USA)). *Health Phys.*; 30: No. 1, 53-59(Jan 1976).

Beagle dogs inhaled aerosols containing $^{144}CeCl_3$. Deposition of $^{144}Ce$ in tissues was determined in serially sacrificed dogs to characterize radiation dose patterns at early times after exposure. Uptakes of $^{144}Ce$ in endocrine glands and reproductive organs were also measured; radiation doses were calculated and those doses were compared with the doses to the major organs of deposition - lung, liver and skeleton. Integrated radiation doses in pituitary and adrenal glands, pancreas, ovaries, testes, prostate and uterus were less than 2 % of those in lung and liver, while the thyroid dose was about 30 % of the dose in liver. These findings were consistent with previously reported biological responses in beagle dogs exposed to high levels of $^{144}CeCl_3$ wherein no radiation effects related to endocrine glands or the reproductive system have been observed. Use of these results in predicting the dosimetry of $^{144}Ce$ in exposed humans re-emphasized the importance of radiation damage to lung, liver, skeleton and gastrointestinal tract compared to other organ systems.

**5758 Studies of injected $^{237}Pu$(IV) citrate in beagles.** Lloyd, R.D.; Atherton, D.R.; McFarland, S.S.; Mays, C.W.; Stevens, W.; Williams, J.L.; Taylor, G.N. (Utah Univ., Salt Lake City (USA). Radiobiology Div.). *Health Phys.*; 30: No. 1, 47-52(Jan 1976).

Three beagles aged 17 months were injected intravenously with about 0.03 $\mu$Ci/kg of the photon emitter $^{237}Pu$(IV) as the citrate. Retention in liver and non-liver tissue was measured serially in the living dogs by a combination of total- and partial-body counting. All excreta were collected throughout the experiment, and blood was sampled at intervals during the first 2 days. About 3/4 of the total excretion was in the feces. The concentration of $^{237}Pu$ in blood plasma decreased from 0.2 % of the injected Pu/ml at 0.5 hr after injection to about 0.02 %/ml at 48 hr, and was indistinguishable from corresponding values for dogs injected with about 0.016 $\mu$Ci/kg of $^{239}Pu$(IV) citrate. After the first few days, total-body retention was between 80 and 90 %, similar to that of other beagles in the colony given $^{239}Pu$ citrate. The dogs injected with $^{237}Pu$ had 50 to 60 % of the injected Pu in the skeleton, while the corresponding values for dogs given $^{239}Pu$ were between 40 and 50 %. Liver retention of $^{237}Pu$ was 20 to 25%, somewhat lower than the 30 to 25 % found for $^{239}Pu$. Although the retention of $^{237}Pu$ in the skeleton was higher than that of $^{239}Pu$, the relative distribution of skeletal $^{237}Pu$ in these dogs which were sacrificed at 13, 20 and 27 days after the injection of about 25 pg Pu resembled that of five dogs given about $2.6 \times 10^6$ pg $^{239}Pu$ and sacrificed less than 1 yr later. Similarities of injected $^{237}Pu$ and $^{239}Pu$ citrate in the beagle were more striking than the observed differences.

**PLANTS**

*REFER ALSO TO CITATION(S) 5689*

## THERMAL EFFECTS

*REFER ALSO TO CITATION(S) 5764*

## CHEMICALS METABOLISM AND TOXICITY

*REFER ALSO TO CITATION(S) 5766*

**5759** (COM—74-11089/AS) **Potential biological effects of hypothetical oil discharges in the Atlantic coast and Gulf of Alaska.** Moore, S.F.; Chirlin, G.R.; Puccia, C.J.; Schrader, B.P. (Massachusetts Inst. of Tech., Cambridge (USA). Dept. of Civil Engineering). Apr 1974. 198p. (MITSG—74-19; NOAA—74051504). NTIS $5.00.

This report is an analysis of the primary biological effects of potential oil discharges resulting from hypothetical oil production activity on the Atlantic/Alaskan OCS. Although emphasis is placed on analysis of impacts and recovery from large-volume infrequent accidental oil spills, small volume continuous discharges of hydrocarbons are also considered. Effects of oil releases from offshore platforms and spills occurring at coastal terminals are assessed. Qualitative predictions are attempted which are a rough order of magnitude estimates of physical, chemical and biological changes likely to occur due to oil releases into the marine environment. The study consists of several principal parts: (1) an environmental inventory; (2) a summary of response and sensitivity of individual organisms to petroleum substances; (3) an analysis of population/community level responses to oil, especially population recovery from accidental spills; and (4) an assessment of potential effects of specific oil discharges associated with hypothetical OCS petroleum developments.

**5760** (ORNL/EIS—96) **NSF-RANN trace contaminants abstracts.** Copenhaver, E.D.; Harnden, D.S. (eds.). (Oak Ridge National Lab., Tenn. (USA)). Jul 1976. Contract W-7405-eng-26. 29p. Dep. NTIS $4.00.

Trace Contaminants Abstracts surveys scientific papers which are published as the result of NAF/RANN project research.

**PLANTS**

*REFER ALSO TO CITATION(S) 5671*

**5761** (UCRL-Trans—1526) **Study of the phytotoxicity of certain components of industrial air pollution.** Dobrovolskii, I.A.; Strikha, E.A. Translated by O. Weres from *Ukr. Bot. Zh.*; **27**: No. 5, 640-644(1970). 18p. Dep. NTIS $3.50.

By the method of biotest (germination of radish seeds and initial growth of seedlings) phytotoxicity was studied of hydrogen sulfide and sulfurous gas, industrial pollutants of the air. The negative effect was established of these gases on germination of seeds, growth and development of seedlings, organs, activity of catalase and other functions. (auth)

**INVERTEBRATES**

*REFER ALSO TO CITATION(S) 5705*

**VERTEBRATES**

*REFER ALSO TO CITATION(S) 5673, 5705, 5720, 5764*

**5762** (ORNL/TIRC—76/2) **Trichloroethylene. I. An impact overview. II. An abstracted literature collection, 1907—1976.** Waters, E.M.; Gerstner, H.B.; Huff, J.E.; Black, S.A. (Oak Ridge National Lab., Tenn. (USA)). May 1976. Contract W-7405-eng-26. 265p. Dep. NTIS $20.00.

This TCE overview provides a narrative survey of the reference literature. Highlights include history, nomenclature, physical and chemical properties, manufacture, analysis, uses, metabolism, toxicology, carcinogenic potential, exposure routes, recommended standards, and conclusions.

**5763** **Acute and chronic toxicity of copper to the fathead minnow in a surface water of variable quality.** Brungs, W.A.; Geckler, J.R.; Gast, M. (Environmental Protection Agency, Cincinnati). *Water Res.*; **10**: No. 1, 37-43(1976).

Acute and chronic toxicity tests conducted with the fathead minnow and copper used as the source of dilution water a natural stream to which a sewage treatment plant upstream contributed a variety of materials known to affect acute copper toxicity. Nominal total copper 96-h median tolerance limit values (96-h TL50), determined with static testing procedures, ranged from 1.6 to 21 mg $l^{-1}$. Dissolved copper 96-h TL50 values ranged from 0.60 to 0.98 mg $l^{-1}$. The maximum acceptable toxicant concentration (MATC) based on survival, growth, reproduction, and hatchability of eggs was between 0.066 and 0.118 mg $l^{-1}$.

**MAN**

*REFER ALSO TO CITATION(S) 5176, 5297, 5666*

## OTHER ENVIRONMENTAL POLLUTANT EFFECTS

**5764** (UCRL—51930(Vol.2)) **Environmental effects of energy production and utilization in the U.S. Volume 2. Public health effects.** Newkirk, H.W. (comp.). (California Univ., Livermore (USA). Lawrence Livermore Lab.). 1 Jun 1976. Contract W-7405-Eng-48. 125p. Dep. NTIS $5.50.

While health hazards from air pollution are observed there is little documenting research for specific toxicity levels. This volume is an attempt to compile all relevant information in one place as a data bank of information that will aid in the required cost-benefit analysis for an energy production or utilization project. Sources include textbooks, journal articles, technical reports, memoranda, letters, and personal communications. The compilation is organized into air pollution, water pollution and land use considerations and cover both radioactive and chemical pollutants. (PCS)

# HEALTH AND SAFETY

**5765** (ERDA—76-23) **Emergency handling of radiation accident cases: firemen.** (Energy Research and Development Administration, Washington, D.C. (USA)). [nd]. 16p. TIC.

Procedures for the emergency handling of persons exposed to radiation or radioactive contamination are presented, with emphasis on information needed by firemen. The types of radiation accident patients that may be encountered are described and procedures for first aid, for preventing the spread of radioactive contamination, and for reporting the accident are outlined. (CH)

**5766** (UCLA-ENG—7425) **Risk of catastrophic spills of toxic chemicals.** Simmons, J.A.; Erdmann, R.C.; Naft, B.N. (California Univ., Los Angeles (USA). School of Engineering and Applied Science). May 1974. Contract E(04-3)-34. 66p. Dep. NTIS $4.50.

This report describes the results of a study to assess the risk to the general population posed by the transportation of chlorine. Here risk means the probability of a single, catastrophic accident having a large adverse impact. Chlorine vapor is toxic, the $LD_{50}$ being approximately 1000 ppm-min at concentrations above 30 to 60 ppm. In the U.S. and Canada, most accidents resulting in the release of ton quantities of chlorine have involved railroad tank cars (capacities ranging from 16 to 90 tons). Accidents involving barges (1100 ton capacity), tank trucks (16 tons capacity), pipelines, small containers, and storage tanks (up to 2000 tons capacity) have resulted in only small releases, measured in pounds. The total number of deaths resulting from all accidents have been relatively few, less than 20, over a fifty year period. (auth)

# GEOSCIENCES

*REFER ALSO TO CITATION(S) 6439*

**5767** (NP—21171) **United States Geological Survey annual report, fiscal year 1975.** (Geological Survey, Washington, D.C. (USA)). 1975. 194p. GPO.

Research programs of the U.S. Geological Survey during fiscal year 1975 are reviewed. Historically, the Geological Survey has had two missions: to provide information about the Earth and its physical resources, and to regulate the activities of lessees engaged in extracting minerals from the public lands. In practical terms the discharge of these responsibilities has required extensive

and continuing investigations of the location, character, and extent of the Nation's mineral, land, and water resources; a continuing program of topographic mapping; and the classification of the mineral and water potential of Federal lands to assure that private parties developing mineral leases meet appropriate standards of safety, environmental protection, and resource conservation, and that the public receives a fair return from the development of its resources. Major emphasis was placed on developing a full range of mineral and energy resource assessments, defining the actual and potential environmental impacts of energy development, and strengthening capabilities to supervise the exploration and development activities implicit in a substantially enlarged oil and gas leasing program for the Outer Continental Shelf. Other programs selected for emphasis were aimed at improving identification of natural hazards, including earthquakes, floods, and volcanic activity, and developing land resource planning tools such as orthophotoquads and land use maps. Public access to map and water-resources information was enhanced by the establishment of information centers to serve as focal points for users who wish to obtain specific and timely data. These and other highlights of fiscal year 1975 are described.

## GEOPHYSICS

### SEISMOLOGY AND TECTONICS

*REFER ALSO TO CITATION(S) 5692, 5774*

**5768** (COO—3134-9) **Comprehensive study of the seismotectonics of the Aleutian Arc. Annual progress report, March 1, 1975—February 29, 1976.** Davies, J.N.; House, L.; Jacob, K.H.; Bilham, R.; Cormier, V.F.; Kienle, J. (Columbia Univ., Palisades, N.Y. (USA). Lamont-Doherty Geological Observatory). 1976. Contract E(11-1)-3134. 76p. Dep. NTIS $5.00.

Seismological and geodetic research performed during the past contract year has increased our understanding of the seismotectonics of the eastern Aleutian Island Arc. While generally aimed at producing a coherent theory for the evaluation of the entire arc, our research has focused on the Shumagin Islands seismic gap, a region within which a major earthquake is expected in the not too distant future. Basic seismological data were collected to investigate certain earthquake prediction techniques.

**5769** (LA—6278-MS) **Seismicity of the Los Alamos area based on geologic data.** Budding, A.J.; Purtymun, W.D. (Los Alamos Scientific Lab., N.Mex. (USA)). Mar 1976. Contract W-7405-eng-36. 7p. Dep. NTIS $3.50.

The seismicity of the Los Alamos area was determined by geologic data from four major faults that offset the Bandelier Tuff. The Bandelier Tuff was deposited as an ashflow about 1.1 million years ago. From geologic data, fault length, displacement, and age of the Bandelier Tuff, it was concluded that the Los Alamos area may experience one shock of a maximum magnitude 5 during a period of 100 years. (auth)

**5770** (LA—6416-MS) **Seismicity of the Los Alamos region based on seismological data.** Sanford, A.R. (Los Alamos Scientific Lab., N.Mex. (USA)). Jun 1976. Contract W-7405-eng-36. 9p. Dep. NTIS $3.50.

Estimates of seismic risk in the Los Alamos area based on only seismological evidence are presented. The data used in the study and tabulated in this paper were restricted to shocks occurring within 111 km of Los Alamos and included noninstrumental reports of earthquakes prior to 1962 and instrumental studies of shocks from 1962 to 1972. The strongest earthquake to occur within the region of study during the 100-yr period, 1872 to 1972, had a probable magnitude of 5.5. Estimates of the strongest shock to occur in a 100-yr period based on extrapolation of the earthquake frequency-magnitude relation range from 3.9 to 5.4 depending on the data set used. The report recommends that seismic risk in the Los Alamos area be based on the recurrence of a magnitude 5.5 earthquake once every 100 yr somewhere within the Rio Grande depression from Albuquerque to Questa. The seismicity of this part of the rift zone is less than the Albuquerque-to-Socorro segment of the same structure and substantially less than equivalent areas in Southern California.

### GEOPHYSICAL SURVEY METHODS

*REFER ALSO TO CITATION(S) 4449, 4704*

**5771** **Methods for generating and shaping a seismic energy pulse.** Itria, O.A. (to Texaco, Inc.). US Patent 3,908,789. 30 Sep 1975. Filed date 30 Oct 1973. vp.

A straight piece of Primacord is suspended in water and detonated by a blasting cap. The primary and surface-reflected pulses are combined to shape the seismic signal by choosing the length and depth of the Primacord and the position of the blasting cap. The effects of the bubble or secondary seismic pulses are reduced because of the elongated bubbles generated.

**5772** **Installation for multiplex transmission of digital signals.** (to Compagnie Generale de Geophysique). US Patent 3,911,226. 7 Oct 1975. Priority date 18 May 1973, France. vp.

The digital signals generated at each geophone station of a seismic line are multiplexed and sent by a single transmission line to a recording unit. Initial pulse signals are generated at a multiplexing frequency by a pulse generator at one end of the transmission line and then sequentially at each geophone station following the digital signals that are relayed down the transmission line to the recording unit.

**5773** **Servo hydraulic transducer and method of operation.** Bedenbender, J.W. (to Texas Instruments Corp.). US Patent 3,929,206. 30 Dec 1975. Filed date 30 Apr 1973. vp.

A smaller than usual engine and pump are required for the hydraulic supply of a seismic vibrator. High-pressure fluid is stored in a large accumulator reservoir, when the vibrator generates the high frequencies of a sweep signal and in between sweeps, and used during the low frequencies of the sweep signal. The hydraulic lifts on each side of the vibrator truck include a chain and sprocket interconnected by a shaft. This arrangement ensures that the hydraulic lifts move together when the weight of the truck is applied to the vibrator.

**5774** **Geophysical methods in geology.** Sharma, P.V. Amsterdam; Elsevier Scientific Publishing Co. (1976). 441p.

An introductory text on geophysical methods in geology is presented. Topics by chapter title include 1) the scope of geophysics and methods, 2) seismic methods, 3) gravity methods, 4) magnetic methods, 5) earth resistivity methods, 6) radiometric methods, 7) geothermal methods, and 8) geophysics applied to global tectonics. (WHK)

**5775** **Geophone case with improved cable anchor.** Hall, E.M. Jr. (to to Walker-Hall-Sears, Inc.). US Patent 3,931,453. 6 Jan 1976. Filed date 23 Aug 1974. vp.

A cable is secured to a cylindrical anchor in the geophone case by passing the cable through 3 bores parallel to the longitudinal axis of the cylinder and the geophone case, thus making two 180-degree bends with the cable.

**5776** **Three-dimensional seismic display.** Anstey, N.A. (to Seiscom Delta, Inc.). US Patent 3,931,609. 6 Jan 1976. Filed date 11 Feb 1974. vp.

A subsurface model of the earth is made by arranging many vertical seismic sections in an egg-crate manner, spaced similar to the seismic profiles from which they came.

**5777** **Vibrator systems for generating elastic waves in the Earth.** Silverman, D. US Patent 3,934,673. 27 Jan 1976. Filed date 1 Feb 1974. vp.

Oscillating fluid flow in and out of a hydraulic cylinder is controlled by an electromechanical or electrohydraulic actuator which drives the hydraulic piston rod. Conduits connect the hydraulic cylinder to one or more seismic vibrators consisting of closed expandable chambers (14′, 14″) supporting a reaction mass and attached to a base plate resting on the ground.

**5778** **Recursion filters for digital processing of potential field data.** Bhattacharyya, B.K. (Univ. of California, Berkeley). *Geophysics;* **41**: No. 4, 712-726(Aug 1976).

From 44. annual international SEG meeting; Dallas, TX, USA (14 Nov 1974).

Zero-phase two-dimensional recursive filters, with a specified frequency domain response, have been designed for processing potential field data. In the case of second vertical derivative filters, it is possible to use the rational approximation of symmetrical functions of a single variable for the design of a short recursive filter. The filter so designed has an excellent response in the frequency domain. For vertical gradient and continuation filters, a method is developed for obtaining, by the least-squares method, a rational expression for a two-dimensional symmetrical function. In order to ensure the stability of the recursive filter, the denominator of the rational expression is approximated by a product of two factors, each being a function of a single variable. Finally, to keep the error of the filter response as small as possible, an iterative procedure is used for adjusting the zeros of the denominator and then determining the coefficients of the numerator of the rational expression.

## MINERALOGY, PETROLOGY, AND ROCK MECHANICS

*REFER ALSO TO CITATION(S) 4679, 4732*

**5779** (UCRL—13665) **High-temperature, low-pressure properties of earth materials.** Raikes, S.; Ahrens, T.J. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Sep 1975. Contract W-7405-ENG-48-3798065. 23p. Dep. NTIS $4.00.

As an initial project in a program of determining high temperature-low pressure equations of state of earth materials, a technique for measuring post-shock temperatures in minerals is described. An InSb detector, operating at 77°K, has been used to determine the post-shock radiance of quartz in the 4 to 5 μm spectral range. Initial tests indicate that such a system can be operated at sensitivities ranging from 0.002 v/°K to 0.01 v/°K in the temperature range 0 to 300°C. Initial shock experiments indicate apparent post-shock temperatures which are very much higher than predicted by Mie-Gruneisen theory and also somewhat higher than is inferred from available release adiabat data.

**5780** **New techniques for measuring rock fracture energy.** Krech, W.W.; Chamberlain, P.G. (Bureau of Mines, Twin Cities, MN). *Soc. Pet. Eng. J.*; **14**: No. 3, 237-242(Jun 1974).

The use of closed-loop, servocontrolled test systems to obtain rock fracture energy measurements in uniaxial tension, torsion, and direct shear is described. Results of fracture energy tests performed on three rock types are presented. Analysis of the test results substantiates the validity of measuring fracture energy by the new test techniques. The advantage of these new tests, providing data potentially useful for input into analytical rock response calculations, far outweighs the advantage, simplicity of test procedure, of the usual test methods. Fracture energy values for three rock types tested under four different load configurations indicate that fracture energy requirements depend upon the type of loading applied to the specimen. The ratio of fracture energy required in uniaxial compression to that required in uniaxial tension ranges from 140 for Berea sandstone to 560 for Barre granite.

## GEOCHEMISTRY

*REFER ALSO TO CITATION(S) 5696, 5700, 5703*

# PHYSICS RESEARCH

## ASTROPHYSICS AND COSMOLOGY

### COSMIC RADIATION

**5781** (N—75-25812) **Measurement of the fluxes of galactic cosmic ray H-2 and He-3 in 1972—1973.** Teegarden, B.J.; Von-rosenvinge, T.T.; Mcdonald, F.B.; Trainor, J.H.; Webber, W.R. (National Aeronautics and Space Administration, Greenbelt, Md. (USA). Goddard Space Flight Center). Apr 1975. 22p. (NASA-TM-X—70901; X—661-75-100). NTIS $3.25.

Submitted for Publication.

If a nearby source of low-energy helium is present, which has traversed a relatively small amount of matter and thus has not caused the production of a significant amount of H-2 or He-3, then these abundance ratios will be suppressed, particularly at low energies. This seems to be the most likely explanation for low ratios. (Author) (GRA)

### STARS

*REFER ALSO TO CITATION(S) 5932*

**5782** (N—75-26942/3ST) **Pulsar average waveforms and hollow cone beam models.** Backer, D.C. (National Aeronautics and Space Administration, Greenbelt, Md. (USA). Goddard Space Flight Center). Jun 1975. 44p. (NASA-TM-X—70917; X—693-75-138). NTIS $3.75.

Submitted for Publication.

An analysis of pulsar average waveforms at radio frequencies from 40 MHz to 15 GHz is presented. The analysis is based on the hypothesis that the observer sees one cut of a hollow-cone beam pattern and that stationary properties of the emission vary over the cone. The distributions of apparent cone widths for different observed forms of the average pulse profiles (single, double/unresolved, double/resolved, triple and multiple) are in modest agreement with a model of a circular hollow-cone beam with random observer-spin axis orientation, a random cone axis-spin axis alignment, and a small range of physical hollow-cone parameters for all objects. (Author) (GRA)

**5783** **Model for the flares of U Geminorum stars.** Gorbatskii, V.G. (Univ., Leningrad). *Sov. Astron. Lett. (Engl. Transl.)*; **1**: No. 1, 11-13(1975).

Translated from Pis'ma Astron. Zh.; 1: No. 1, 23-28(Jan 1975).

All the phenomena observed during flares of stars of the U Gem type may be regarded as consequences of energy instability in the secondary component. The brightening of the companion is accompanied by a substantial increase in the mass flow toward the disk-shaped envelope around the primary component. As a result the radiation of the disk, especially its central portion, predominates at maximum light.

**5784** **Circular polarization in magnetic stars.** Pavlov, G.G.; Shibanov, Ya.A.; Gnedin, Yu.N. (Ioffe Inst. of Physics and Tech., Leningrad). *Sov. Astron. AJ (Engl. Transl.)*; **19**: No. 5, 579-584(1975).

Translated from Astron. Zh., 52: No. 5, 956-964(1975).

A general expression is obtained for the spectral dependence of the degree of circular polarization in a magnetic star, assuming LTE and an inhomogeneous magnetic field. Approximate analytic equations are then derived for the limiting cases where the absorption coefficient is large or small compared to its frequency-averaged value. The polarization due to free-free transitions is examined in detail. As the inhomogeneity of the magnetic field on the stellar surface increases, the circular polarization in the high-frequency range declines more gradually with frequency and the polarization maximum shifts toward higher frequencies. The polarization maximum is located at a higher frequency than the maximum in the radiant-intensity curve, so that optical sources may be expected to be more strongly polarized in the ultraviolet range. 17 references.

**5785** **Kinetic inhomogeneity of G-type dwarfs.** Gotska, T.G. (State Pedagogical Inst., Rostov-on-Don, USSR). *Sov. Astron. AJ (Engl. Transl.)*; **19**: No. 5, 616-618(1975).

Translated from Astron. Zh., 52: No. 5, 1017-1020(1975).

On the basis of the statistics of the velocities and elements of galactocentric orbits of near stars, the G-type dwarfs are associated with the disk (delta(U-B) less than or equal to 0.115m and intermediate (delta (U-B) greater than or equal to 0.115m) subsystems of the Galaxy. The stars with ultraviolet excess 0.015m less than delta(U - B) less than 0.115m form an inhomogeneous group. 10 references.

**5786** **Evidence for an 11.2 day periodicity from Cygnus X-2.** Holt, S.S. (Goddard Space Flight Center, Greenbelt, MD); Boldt, E.A.; Serlemitsos, P.J.; Kaluzienski, L.J. *Astrophys. J., Lett.*; **205**: No. 3, L143-L145(1 May 1976).

Evidence for a persistent 11/sup d/.17 +- 0/sup d/.10 period from Cyg X-2 is presented from one year of accumulated data from the Ariel-5 All-Sky Monitor. The effect is not a simple sidereal alias of a true source period close to one day.

**5787** **IRC+10 420: A hot supergiant maser.** Giguere, P.T.; Woolf, N.J.; Webber, J.C. (Theoretical Division, Los Alamos Scientific Laboratory). *Astrophys. J., Lett.*; **207**: No. 3, L195-L198(1 Aug 1976).

IRC+10 420, of spectral type F8 Ia, is a maser in the OH molecule's ground-state lines at 1612, 1665, and 1667 MHz. Two 1612 MHz components are separated by 58 km $s^{-1}$, with peak fluxes of 47 and 7 Jy. Upper limits are given for the 1720 MHz OH line and the 22,235 MHz $H_2O$ line. New infrared data are also presented. (AIP)

**5788** **A single-star interpretation of Nova Cygni 1975.** Starrfield, S.; Truran, J.W.; Gallagher, J.S.; Sparks, W.M.; Strittmatter, P.; Van Horn, H.M. (Department of Physics, Arizona State University). *Astrophys. J., Lett.*; **208**: No. 1, L23-L25(15 Aug 1976).

Observational evidence has revealed that Nova Cygni 1975 is not a typical nova event. We suggest that Nova Cygni is to be understood, not in terms of a canonical close binary system, but essentially as a single star undergoing a thin-shell thermonuclear explosion. (AIP)

**5789** **A suggestion for the alternating amplitudes of RV Tauri variables.** Deupree, R.G.; Hodson, S.W. (Theoretical Division, Los Alamos Scientific Laboratory, University of California). *Astrophys. J.*; **208**: No. 2, 426-427(1 Sep 1976).

Based on two-dimensional hydrodynamical calculations, it is suggested that the origin of the alternating amplitudes of RV Tauri variables lies in time-dependent convection. Calculations indicate

that, under certain conditions, large-amplitude convective motion may get damped out every other period. The primary condition appears to be that the convective velocities be large (very near the sound speed). Such is likely the case for such luminous and cool stars as the RV Tauri variables. (AIP)

**5790 The geometry of the eclipse of a pointlike star by a Roche-lobe-filling companion.** Chanan, G.A.; Middleditch, J.; Nelson, J.E. (Lawrence Berkeley Laboratory, University of California, Berkeley). *Astrophys. J.*; **208**: No. 2, 512-517(1 Sep 1976).

For binary systems of this type, which may be representative of certain X-ray sources, the eclipse duration defines a relation between the mass ratio and orbital inclination of the system; we have derived and tabulated this relation. Eclipse geometry for binary systems in which both stars fill their Roche lobes is also discussed briefly. (AIP)

**5791 Studies of optical pulsations from HZ Herculis/Hercules X-1: A determination of the mass of the neutron star.** Middleditch, J.; Nelson, J. (Lawrence Berkeley Laboratory, University of California, Berkeley). *Astrophys. J.*; **208**: No. 2, 567-586(1 Sep 1976).

In 500 hours of optical observations of this binary system we have repeatedly detected optical pulsations at the 0.1—0.3 percent level. These pulsations are present only for particular well-defined values of the binary and 35-day phases. Position of the pulsation-emitting regions, projected onto the orbital plane, have been measured, and three distinct regions have been resolved. A simple model is put forth which accounts for the observed binary behavior, which gives a direct determination of the mass ratio, M/sub HZHer//M/sub HerX-/$_i$=1.68 +- 0.10 and which establishes that the spin of the pulsar is prograde. Additionally, it is shown that Hz Her fills its Roche lobe. Using the above, the known X-ray eclipse duration, and the mass function, we calculate the orbital inclination to be i=87degree +- 3degree and the masses to be M/sub HerX-/$_i$=1.30 +- 0.14 M/sub sun/ and M/sub HZHer/=2.18 +- 0.11 M/sub sun/. (AIP)

**5792 Stellar neutron capture in the thallium isotopes.** Macklin, R.L.; Winters, R.R. (Oak Ridge National Laboratory). *Astrophys. J.*; **208**: No. 3, 812-818(15 Sep 1976).

High-resolution neutron capture cross section data for isotopically enriched samples of $^{203}$Tl and $^{205}$Tl were taken at the Oak Ridge Electron Linear Accelerator time-of-flight facility. The resonance parameter data were used to calculate neutron capture probabilities over a range of stellar interior temperatures. A semiempirical estimate is also interpolated for the radioactive $^{204}$Tl and $^{208}$Pb, and the results are used to recalculate the time scale of s-process nucleosynthesis. (AIP)

**5793 CNO abundances and hydrodynamic models of the nova outburst. IV. Comparison with observations.** Sparks, W.M.; Starrfield, S.; Truran, J.W. (NASA/Goddard Space Flight Center). *Astrophys. J.*; **208**: No. 3, 819-825(15 Sep 1976).

A variety of observations of novae are discussed in light of our theoretical models. We propose that the nearly constant bolometric luminosity of FH Ser observed by Gallagher and Code originates in the nondegenerate hydrogen-burning region at the bottom of the hydrogen-rich envelope which remains after the primary ejection. The shift of the wavelength of peak emission from the visual to shortward of the ultraviolet is caused by the decrease of the photospheric radius of the remnant envelope as the bolometric luminosity stays nearly constant. The oscillations in the light curve of GK Per during the transition stage can be explained by a pulsation of the remnant envelope when it is larger than the semimajor axis of the binary system. The CNO overabundances in novae reported by various observers are strongly suggestive of our nova mechanism. Finally, the implications of the upper limits of $^{13}$C and $^{15}$N found by Sneden and Lambert in DQ Her are discussed. (AIP)

## QUASI-STELLAR, RADIO, AND X-RAY SOURCES

**5794 An X-ray survey of BL Lacertae objects.** Margon, B.; Bowyer, S.; Jones, T.W.; Davidsen, A.; Mason, K.O.; Sanford, P.W. (Space Sciences Laboratory, University of California, Berkeley). *Astrophys. J.*; **207**: No. 2, 359-363(15 Jul 1976).

X-ray observations of four BL Lacertae objects (BL Lac, W Com [=ON 231], ON 325 [=B2 1215+30], and AP Lib) have been obtained in the 2.5—7.5 keV band, using the collimated proportional counter aboard OAO Copernicus. None of the objects was detected, with typical 2 $\sigma$ upper limits of 1 x $10^{-10}$ ergs $cm^{-2}$ $s^{-1}$ set upon fluxes incident at Earth. Near-simultaneous photographic photometry was also obtained for each object; all proved to be at the faint end of their respective variability ranges. The data are used to derive limits on the brightness temperature and angular size of the compact nonthermal radio sources; for W Com, ON 325, and AP Lib, these are the first such limits, since no VLBI results are available. By using limits on the physical source sizes deduced from radio variability, upper limits on the distances to the objects are obtained. The most stringent of these is for BL Lac, indicating D>240 Mpc. Evidence for intraday photometric variability of ON 325 is also noted. (AIP)

**5795 Optical pulsations in HZ Herculis. V. Pulse-resolved spectrophotometry.** Margon, B.; Davidsen, A.; Bowyer, S. (Space Sciences Laboratory, University of California, Berkeley). *Astrophys. J., Lett.*; **208**: No. 1, L35-L39(15 Aug 1976).

We have obtained digital spectra of HZ Herculis with 10 A resolution in the 3600—6000 A region, synchronously dividing the 1.24 s optical pulsation period into eight 155 ms phase bins. The optical pulses are detected in the data, but their fractional amplitude is only 0.08 percent, a factor of 4 less than typically observed. The separate spectra of each one-eighth of the pulse are identical to within the statistics of the observation. If the X-ray to optical pulse reprocessing mechanism concentrates the optical pulsations into discrete spectral line features, our data require the pulses to be distributed among more than four such lines. (AIP)

**5796 Parameter estimation in X-ray astronomy.** Lampton, M.; Margon, B.; Bowyer, S. (Space Science Laboratory, University of California, Berkeley). *Astrophys. J.*; **208**: No. 1, 177-190(15 Aug 1976).

The problems of model classification and parameter estimation are examined, with the objective of establishing the statistical reliability of inferences drawn from X-ray observations. For testing the validities of classes of models, the procedure based on minimizing the chi$^2$ statistic is recommended; it provides a rejection criterion at any desired significance level. Once a class of models has been accepted, a related procedure based on the increase of chi$^2$ gives a confidence region for the values of the model's adjustable parameters. The procedure allows the confidence level to be chosen exactly, even for highly nonlinear models. Numerical experiments confirm the validity of the prescribed technique.The chi$^2$/sub min/+1 error estimation method is evaluated and found unsuitable when several parameter ranges are to be derived, because it substantially underestimates their joint errors. The ratio of variances method, while formally correct, gives parameter confidence regions which are more variable than necessary. (AIP)

**5797 Identification and redshift of the triple radio source 3C 154.** Spinrad, H.; Liebert, J. (Department of Astronomy, University of California, Berkeley). *Astrophys. J.*; **208**: No. 2, 292-295(1 Sep 1976).

The triple radio source 3C 154 is centered on a 17.5 mag QSO with z=0.580. The optical spectrum is Seyfert-like. The outer radio lobes are separated by 43", or about 375 kpc (for $H_o$=50, $q_o$=0) in projection, making 3C 154 among the larger sources in linear size. We have used a simple expansion model to determine that the characteristic outburst time scale is longer than 6 million years. (AIP)

## SOLAR PHENOMENA

*REFER ALSO TO CITATION(S) 5823, 5838*

**5798** (N—75-22343) **Real-Time Solar Magnetograph Skylab mission atlas.** Hagyard, M.J.; Cumings, N.P. (National Aeronautics and Space Administration, Huntsville, Ala. (USA). George C. Marshall Space Flight Center). Mar 1975. 106p. (NASA-TM-X—64922). NTIS $5.25.

An atlas of all magnetic field observations made during the Skylab missions with the Real Time Solar Magnetograph system located at the Marshall Space Flight Center is presented. Also included are a description of the system and its operation; an outline of the data reductions performed; and a discussion of probable errors, noise, magnetic sensitivity, and system reliability. (auth)

**5799** (N—75-26937/3ST) **The 1973 solar occultation of the Crab Nebula pulsar.** Weisberg, J.M. (Iowa Univ., Iowa City (USA). Dept. of Physics and Astronomy). May 1975. Contract NGL-16-001-002. 72p. (NASA-CR—142984). NTIS $4.25.

The mean electron density of the solar corona was determined by measuring the dispersion of radiofrequency pulses from pulsar NP 0532 during the June 1973 solar occultation. Trends continued which were noticed in 1971 as solar activity declined. Model fitting results suggest that the corona continued to become even more concentrated toward the equator in 1973 than in 1971. The number density of electrons in most regions decreased. The best model of the distribution of corona electrons is suggested to be one with zero density at the poles. K-corona isophotes and contours of equal path-integrated density are presented for several models. Electron density versus date and position in the corona are

tabulated. It is seen that there is no simple relationship between the onset of major solar activity and density or scattering enhancements. (Author) (GRA)

**5800 Why few lines of the Balmer series are observed in flares on the disk.** Kurochka, L.N.; Sitnik, G.F. (Kiev State Univ.). *Sov. Astron. AJ (Engl. Transl.)*; **19**: No. 5, 590-591(1975).

Translated from Astron. Zh., 52: No. 5, 975-977(1975).

It is shown that the populations of the upper levels of hydrogen atoms in flares starting with the 10th level are distributed according to the statistical weights of the levels, and that the optical thicknesses in the far Balmer lines are considerably less than unity. Thanks to these two conditions the intensities of the higher lines of the Balmer series must decrease rapidly with number, which results in the small number of observed lines in flares on the disk. The population of the second level of hydrogen atoms and the emission measures in flares are also estimated.

**5801 Fast solar electrons, interplanetary plasma and km-wave type-III radio bursts observed from the IMP-6 spacecraft.** Alvarez, H. (Michigan Univ., Ann Arbor (USA)); Lin, R.P. (California Univ., Berkeley (USA). Space Sciences Lab.); Bame, S.J. (Los Alamos Scientific Lab., N.Mex. (USA)). *Sol. Phys.*; **44**: No. 2, 485-501(Oct 1975).

IMP-6 spacecraft observations of low frequency radio emission, fast electrons, and solar wind plasma are used to examine the dynamics of the fast electron streams which generate solar type-III radio bursts. Of twenty solar electron events observed between April 1971 and August 1972, four were found to be amenable to detailed analysis. Observations of the direction of arrival of the radio emission at different frequencies were combined with the solar wind density and velocity measurements at 1 AU to define an Archimedean spiral trajectory for the radio burst exciter. The propagation characteristics of the exciter and of the fast electrons observed at 1 AU were then compared. It is found that: (1) the fast electrons excite the radio emission at the second harmonic; (2) the total distance travelled by the electrons was between 30 and 70% longer than the length of the smooth spiral defined by the radio observations; (3) this additional distance travelled is the result of scattering of the electrons in the interplanetary medium; (4) the observations are consistent with negligible true energy loss by the fast electrons.

**5802 Coronal emission line profile observations at total solar eclipses. I. Airborne instrumentation and results.** Liebenberg, D.H. (Los Alamos Scientific Lab., N.Mex. (USA)). *Sol. Phys.*; **44**: No. 2, 331-344(Oct 1975).

A 25-cm aperture f/8.0 telescope was operated aboard a U.S. Air Force-Energy Research and Development Administration aircraft at the 30 May 1965 and 12 November 1966 total solar eclipses. A fixed path Fabry-Perot interferometer spectrograph with 0.008-nm resolution was developed to photographically record intensity vs wavelength profiles of the coronal emission lines Fe XIV (530.3 nm), Fe X(637.4 nm) and Ca XV (569.4 nm). A pressure scanned Fabry-Perot interferometer was developed with a photoelectric detector and recorder. Photoelectric tracking was used in 1965 and gyroscopic tracking with photoelectric updating provided improved tracking in 1966. Photographic interferometer data were obtained out to 1.79 R(sun) in 1965 at 530.3 nm. Doppler shifts are determined and indicate generally small velocities of coronal material. Results in Fe XIV and Fe X were obtained in 1966. No Ca XV emission was detected in 1966.

**5803 Coronal emission line profile observations at total solar eclipses. II. 30 May 1965 results, deconvolution and interpretation.** Liebenberg, D.H. (Los Alamos Scientific Lab., N.Mex. (USA)); Bessey, R.J.; Watson, B. (Wyoming Univ., Laramie (USA)). *Sol. Phys.*; **44**: No. 2, 345-359(Oct 1975).

High resolution spectra of the coronal emission line Fe XIV at 530.3 nm obtained at the 30 May 1965 total solar eclipse are analyzed and interpreted. Deconvolution techniques that preserve the line intensity vs wavelength profile shape are developed to obtain further resolution improvement. The west limb coronal enhancement is determined to have temperatures less than 3 MK and turbulent velocities of approximately 25 $kms^{-1}$ decreasing with altitude. Temperature gradients provide evidence for marginal solar wind flow from this enhancement. Above the quiet photosphere in the southwest quadrant the comparison of line and continuum intensities and consideration of line width suggest to us the coronal region is filled with inhomogeneous plasma, dense enough in localized regions to maintain collisional excitation. Solar wind flow from this region obtains when turbulent velocities are assumed to contribute to the line broadening. This region is identified as a coronal hole and it is suggested that coronal material is heated by the quiet photosphere below.

## GALAXIES

**5804 (N—75-25785) Radio observations of interstellar CH. Part 1.** Rydbeck, O.E.H.; Kollberg, E.; Hjalmarson, A.; Sume, A.; Ellder, J. (Chalmers Tekniska Hoegskola, Goeteborg (Sweden)). Mar 1975. Contract NGL-22-010-023. 303p. (NASA-CR—142977). NTIS $9.25.

Galactic observations of interstellar CH are presented. The observations are made with a traveling wave maser preamplifier, in the Onsala 25.6 telescope. This gives a zenith system noise temperature of about 34 K. Other interstellar gas species (such as CO, H2) are studied also. Theoretical considerations of excitation temperature and optical depth calculations are given. The CH energy level structure of the lowest ratational states is discussed in relation to the excitation of the radical by collisions. It is postulated that the deficiency in very dense molecular clouds is due to the radical being consumed by the formation of the observed, more complex molecules. No good agreement is found between the observations and existing theories of interstellar CH formation, which seem to underestimate the CH abundance. (Author) (GRA)

**5805 (N—75-26939/9ST) The spectral energy distribution of NGC 1275.** Shields, G.A.; Oke, J.B. (Hale Observatories, Pasadena, Calif. (USA)). 1975. Contract NGL-05-002-134. 19p. (NASA-CR—143039). NTIS $3.25.

An analysis of absolute spectral energy distributions of interstellar gas for a galaxy (NGC 1275) is presented. Infrared spectra data shows heavy reddening. It is proposed that the interstellar gas may be ionized by shock waves or by nonthermal or stellar radiation. It is suggested, that high velocity, emission-line knots are H2 regions in a Perseus cluster galaxy or intergalactic gas cloud seen in projection against NGC 1275. (Author) (GRA)

**5806 Existence of multiple clusters of galaxies.** Karachentsev, I.D.; Tsarevskaya, R.L.; Shcherbanovskii, A.L. (Astrophysical Observatory, Moscow). *Sov. Astron. AJ (Engl. Transl.)*; **19**: No. 5, 606-610(1975).

Translated from Astron. Zh., 52: No. 5, 999-1006(1975).

The distribution of Abell's clusters of galaxies with different distance and richness classes is analyzed by counting the number of clusters within r less than or equal to $6^0$ of clusters and around randomly chosen centers. Some indications have been found confirming the reality of a spatial clustering of the clusters. The distribution of clusters can be represented by a model of simple clustering with the following parameters: mean population of the multicluster (k + 1) = 2.10 +- 0.11 clusters, mean diameter of multicluster (D) = 20.2 +- 3.3 Mpc, and relative number of individual clusters Q(0) = 0.42 +- 0.04. The structure of a multicluster corresponds to a normal distribution law of the density. The distribution of multiclusters over the populations is expressed approximately by the law Q[k + 1] = 2/sup -(k + 1)/. 12 references.

**5807 Upper limits to the interstellar radiation field between 775 and 1050 A.** Paresce, F.; Bowyer, S. (Space Sciences Laboratory, University of California, Berkeley). *Astrophys. J.*; **207**: No. 2, 432-435(15 Jul 1976).

A 40 A resolution extreme ultraviolet spectrometer, sensitive to radiation in the 775—1050 A band, was flown on a Black Brant VC rocket to measure the night sky brightness in this region of the electromagnetic spectrum. A weak signal above background was recorded in most channels as the spectrometer's 6degree x 7degree field of view scanned the sky in the vicinity of the galactic plane from Monoceros to Andromeda. Because the Earth's upper atmospher may produce some radiation in this wavelength region, we cannot exclude the possibility that some or all of the observed signal is terrestrial in origin. However, we can establish observational upper limits at the 95 percent confidence level for the intensity of an extraterrestrial extreme ultraviolet background which ranges from 6 x $20^{-8}$ ergs $cm^{-1}$ $s^{-1}$ $sr^{-1}$ A at 1050 A to 4 x $10^{-7}$ ergs $cm^{-2}$ $s^{-1}$ $sr^{-1}$ $A^{-1}$ at 775degree. These results are consistent with existing theoretical predictions. (AIP)

**5808 Oscillation and collapse of interstellar clouds.** Weber, S.V. (Department of Astronomy, University of California, Berkeley). *Astrophys. J.*; **208**: No. 1, 113-126(15 Aug 1976).

The gross internal dynamics of interstellar clouds are studied by means of the tensor virial equations. To evaluate the virial integrals, clouds are approximated as compressible ellipsoids, uniform in density, bounded by external pressure, and with velocities linear in the coordinates. Rigidly rotating spheroidal equilibrium states exist for any external pressure, but those at high pressure are distortionally unstable. Elongated rigidly rotating equiliba also exist, but not if the external pressure is sufficiently high. Numerical integration of the dynamic equations demonstrates that clouds of low angular momentum can collapse by several orders of magnitude in density even while remaining axially symmetric. Collapse

with the conservation of angular momentum is also possible for clouds of high angular momentum if they attain a specific elongated configuration. The transition between the behavior of clouds of low and high angular momentum is surprisingly abrupt. (AIP)

**5809 The prospects for astronomical optical rotatory dispersion studies.** Giguere, P.T.; Snyder, L.E.; Richardson, F.S. (Theoretical Division, Los Alamos Scientific Laboratory). *Astrophys. J.*; **208**: No. 2, 365-368(1 Sep 1976).

The measurement of the relative populations of right- and left-handed isomers of interstellar optically active molecules is considered. Emphasis is given to the amino acid alanine. It is shown that a column density of alanine molecules in pure D or L form $\sim 10^{17}$—$10^{18}$ $cm^{-2}$ will be required to detect the ultraviolet optical rotatory dispersion (ORD) effect in alanine with a polarimeter that can detect a relative linear polarization position angle difference of 0.1°. Unusually strong infrared vibrational ORD is preferable to the ultraviolet effect. (AIP)

**5810 An almost complete survey of 21 centimeter line radiation for vertical-barbvertical-bar> or =10degree. VI. Energetic expanding H I shells.** Heiles, C. (Department of Astronomy, University of California, Berkeley). *Astrophys. J., Lett.*; **208**: No. 3, L137-L139(15 Sep 1976).

H I, when viewed in narrow velocity ranges, is concentrated in arcs with typical diameters of tens of degrees. In some cases the diameters change with velocity in the manner expected for expanding shells. The clearest example appears to be consistent with a model involving an old supernova explosion. Much of the interstellar volume is probably contained with H I shells. (AIP)

**5811 Observations of interstellar helium with a gas absorption cell: Limits on the bulk velocity of the interstellar medium.** Freeman, J.; Paresce, F.; Bowyer, S.; Lampton, M. (Space Sciences Laboratory, University of California, Berkeley). *Astrophys. J.*; **208**: No. 3, 747-752(15 Sep 1976).

A photometer sensitive at the 584 A line of He I, incorporating a helium gas absorption cell, was flown on a sounding rocket launched from White Sands on 1974 November 25. In flight, the gas cell was alternately filled and evacuated with helium of sufficient density to absorb 584 A radiation scattered from geocoronal helium at $10^3$ K.The photometer observed the sky in Perseus at ecliptic longitude 60degree, ecliptic latitude +20degree, from altitudes of 160 to 185 km. An upper limit to the nighttime geocoronal 584 A flux of 0.09 +- 0.74 rayleighs is derived. The ratio of fluxes seen with cell full and cell empty is 0.96 +- 0.24. A comparison of this datum with numerical models of the flow of interstellar helium through the solar system, using directions of motion derived by other experiments, sets a lower limit of 10—15 km $s^{-1}$, at the 95 percent confidence level, on the bulk speed of the interstellar medium far from the Sun. The results reported may alternatively be interpreted as indicating that present models of the local behavior of the interstellar medium are inadequate. (AIP)

**5812 Collisional excitation of Λ doublet transitions in CH and OH.** Bertojo, M.; Cheung, A.C.; Townes, C.H. (Department of Physics, University of California, Berkeley). *Astrophys. J.*; **208**: No. 3, 914-922(15 Sep 1976).

Excitation of the lowest Λ doublet levels of CH and OH by collisions with H, $H_2$, and He and subsequent radiative decay is calculated on the basis of the $H_2CO$ rotational doublet levels. Molecular asymmetry plays an important role. It is shown that under a wide range of temperatures and densities characteristic of interstellar clouds, population of the Λ doublet of CH will very likely be inverted by collisions with H, $H_2$, or He. This appears to account for the emission and maser amplification frequency found for this transition of CH. The approximations used give less certain results for excitation of the Λ doublet in OH, but indicate that collisions with H may produce a population inversion, while those with $H_2$ or He have the opposite effect, giving an excess population in the lower of two Λ doublet levels. (AIP)

## COSMOLOGY

**5813 Gravitational lenses and velocities faster than light.** Ingel, L.Kh. *Sov. Astron. Lett.* (*Engl. Transl.*); **1**: No. 2, 54(1975).

Translated from Pis'ma Astron. Zh.; 1: No. 3, 18-20(Mar 1975).

The pair of images of the same object formed by a moving gravitational lens can have a relative velocity greater than the speed of light.

**5814 Globally inhomogeneous "spliced" universes.** Sokolov, D.D.; Starobinskii, A.A. (Moscow State Univ.). *Sov. Astron. AJ* (*Engl. Transl.*); **19**: No. 5, 629-633(1975).

Translated from Astron. Zh., 52: No. 5, 1041-1048(1975).

Topologically "spliced" Friedmann spaces with less than the critical density are considered. The concept of a G-domain (for "ghost" images) is introduced, wherein the minimum splicing parameter is shorter than the typical distance between galaxy clusters. The behavior of small adiabatic perturbations of such spaces is investigated, and it is shown that neither galaxy clusters nor galaxies and quasars can form within a certain type of G-domain. All perturbation modes are assumed statistically independent and all modes of the same scale are considered equally probable. While the earth definitely is not located in a G-domain, these domains could in principle be situated at distances of the same order as the radius of curvature of the universe (z approximately 1.7 if rho is much less than rho/sub c/). Their existence would be a manifestation of the global inhomogeneity of spliced universes, whereby the splicing parameters would vary from point to point. A search for G-domains might either establish that our universe is in fact spliced, or at least raise the estimate of the minimum splicing parameter to several tens of megaparsecs. 10 references.

**5815 Conference: hidden mass in the Universe.** Doroshkevich, A.G.; Iyeveer, M.M.; Einasto, Ya.E. *Sov. Astron. AJ* (*Engl. Transl.*); **19**: No. 5, 668-670(1975).

Translated from Astron. Zh., 52: No. 5, 1113-1115(1975).

Papers presented at the conference are briefly discussed. (BJG)

## PLANETARY PHENOMENA

**5816** (N—75-22229) **Modelling the magnetosphere of Mercury.** Whang, Y.C.; Ness, N.F. (National Aeronautics and Space Administration, Greenbelt, Md. (USA). Goddard Space Flight Center). Apr 1975. 23p. (NASA-TM-X—70873; X—690-75-89). NTIS $3.25.

Submitted for Publication.

A model magnetosphere for Mercury is presented using an upstream image-dipole and nightside 2-dimensional tail current sheet method. The tail field is represented by an analytical formulation. Magnetic field data from the Mercury 1 encounter by Mariner 10 in March 1974 are used to determine quantitative parameters of the model magnetosphere, using the method of least squares. The magnetopause crossing points directly observed are used to determine the size of the magnetosphere, and the solar wind conditions are used to determine the magnetospheric field at the stagnation point. The model produces a magnetosphere-like region with planetary field lines that are confined in nearly circular cross-sections transverse to the sun-planet line. Results are used to show geometry, field line configuration, and contours of constant field intensity inside the magnetosphere.

**5817** (N—75-23920) **Earth radiation budget measurement from a spinning satellite: conceptual design of detectors.** Sromovsky, L.A.; Revercomb, H.E.; Suomi, V.E. (Wisconsin Univ., Madison (USA). Space Science and Engineering Center). Apr 1975. Contract NAS1-13204. 239p. (NASA-CR—132494). NTIS $7.50.

The conceptual design, sensor characteristics, sensor performance and accuracy, and spacecraft and orbital requirements for a spinning wide-field-of-view earth energy budget detector were investigated. The scientific requirements for measurement of the earth's radiative energy budget are presented. Other topics discussed include the observing system concept, solar constant radiometer design, plane flux wide FOV sensor design, fast active cavity theory, fast active cavity design and error analysis, thermopile detectors as an alternative, pre-flight and in-flight calibration plane, system error summary, and interface requirements. (GRA)

**5818** (N—75-24632) **Jupiter: as a planet.** (National Aeronautics and Space Administration, Washington, D.C. (USA)). 1975. 4p. (NASA-TM-X—66828). NTIS $3.25.

The planet Jupiter, its planetary mass and atmosphere, radio waves emitted from Jupiter, thermal radiation, internal structure of Jupiter, and the possibility of life on Jupiter are discussed. Educational study projects are included. (GRA)

**5819** (N—75-24624) **Results of investigating the Martian atmosphere by radio-occultation using the Mars-2, Mars-4, and Mars-6 craft.** Kolosov, M.A.; Yakovlev, O.I.; Yakovleva, G.D.; Yefimov, A.I.; Trusov, B.P. Translated from *Kosm. Issled.*; **133501**: No. 1, 54-59(1975). 10p. (NASA-TT-F—16341). NTIS $3.25.

For the region with latitude -52 deg, longitude 70 deg, near-surface pressure was found to be 6.7 mbar. For solar zenith angles 82-72 deg, the principal ionospheric maximum with electron concentration (7.1-9.3 times 10,000/cm) begins to appear at the altitudes 135-145 km, while at a solar zenith angle of 50 deg, the maximum electron concentration is 1.7 (10,000/cu cm). The scale of altitudes in the upper part of the daytime ionosphere has the value 32-38 km. The daytime Martian ionosphere has a second

ionospheric maximum at the altitude 110-115 km. (Author) (GRA)

**5820** (N—75-24625) **Preliminary results of two-frequency radio-occultation of the Mars ionosphere by means of Mars planetary probes in 1974.** Vasilyev, M.B.; Vyshlov, A.S.; Kolosov, M.A.; Savich, N.A.; Samovol, V.A. Translated from *Kosm. Issled.*; **13**: No. 1, 48-53(1975). 10p. (NASA-TT-F—16340). NTIS $3.25.

The two-frequency radio-occultation of the Mars ionosphere by Mars-4 on 10 February 1974 and Mars 6 on 12 March 1974 was carried out to determine the altitudinal distribution of electron concentration in the Martian atmosphere above the nighttime and daytime sides of the planet. In the space and ground-based interferometer system, both frequency signals were received and processed to produce phase differences and frequency differences as a function of time and beam elevation above the Martian surface. Detailed curves representing these Mars-4 data are shown. (Author) (GRA)

**5821** **Heterodyne detection of $CO_2$ emission lines and wind velocities in the atmosphere of Venus.** Betz, A.L.; Johnson, M.A.; McLaren, R.A.; Sutton, E.C. (Department of Physics, University of California, Berkeley). *Astrophys. J., Lett.*; **208**: No. 3, L141-L144(15 Sep 1976).

Strong 10 $\mu$ line emission from $^{12}C^{16}O_2$ in the upper atmosphere of Venus has been detected by heterodyne techniques. Observations of the absolute Doppler shift of the emission features indicated mean zonal wind velocities less than 10 m $s^{-1}$ in the upper atmosphere near the equator. No evidence was found of the 100 m $s^{-1}$ wind velocity implied by the apparent 4 day rotation period of ultraviolet cloud features. (AIP)

**5822** **Nonthermal 10 micron $CO_2$ emission lines in the atmospheres of Mars and Venus.** Johnson, M.A.; Betz, A.L.; McLaren, R.A.; Sutton, E.C.; Townes, C.H. (Department of Physics, University of California, Berkeley). *Astrophys. J., Lett.*; **208**: No. 3, L145-L148(15 Sep 1976).

Mechanisms are examined for excitation of strong 10 $\mu$ $CO_2$ emission lines seen on Mars and Venus. Line absorption of near-infrared solar flux directly by $CO_2$ or by $H_2O$ with collisional transfer of energy to $CO_2$ are proposed as likely excitation mechanism. Altitudes for peak 10 $\mu$ emission are estimated to be near 80 km for Mars and 120 km for Venus. (AIP)

## ATMOSPHERIC PHYSICS

**5823** **Ion chemistry of $N_2^+$ and the solar ultraviolet flux in the thermosphere.** Oppenheimer, M.; Dalgarno, A.; Brinton, H.C. (Center for Astrophysics, Harvard College Observatory and Smithsonian Astrophysical Observatory Cambridge, Massachusetts 02138). *J. Geophys. Res.*; **81**: No. 22, 3762-3766(1 Aug 1976).

We have analyzed daytime composition measurements in the thermosphere from Atmosphere Explorer-C by use of a theory of the ion chemistry. We compare predicted and measured $N_2^+$ densities in order to infer global variations of the solar ionizing flux. Our results indicate that the solar flux of Hinteregger measured on Atmosphere Explorer-C provides an adequate basis for the calculation of solar ultraviolet photo-ionization rates. The role of metastable species is examined, and theoretical $O^+(^2D)$ densities are presented. (AIP)

### AURORAL AND IONOSPHERIC PHENOMENA

*REFER ALSO TO CITATION(S) 5829*

**5824** (AD-A—013719/0ST) **Band model calculation of atmospheric transmittance for hot gas line emission sources. Account of Doppler broadening. Interim report.** Young, S.J. (Aerospace Corp., El Segundo, Calif. (USA). Chemistry and Physics Lab.). 30 Jul 1975. Contract F04701-75-C-0076;DARPA Order-2843. 62p. NTIS $4.25.

See also report dated 31 Dec 1974, AD-A—005632.

The effective transmittances along a slant path from the source altitude to space at a zenith angle of 75 deg are computed and averaged over three wide bandpasses in the 2.7 micrometer spectral region. Statistical band model calculations are performed for the assumption that the emission-absorption lines have a Lorentz, Doppler, or Voigt profile. Inhomogeneities inherent in treating the line of sight through the and the hot gas source as a single, highly inhomogeneous optical path are accounted for by using either the Curtis-Godson, the Lindquist-Simmons, or the two-path derivative approximation. The latter is derived herein and is shown to be superior to the Lindquist-Simmons approximation in treating radiative transfer calculations for the Doppler or Voigt line shape. With line shape properly accounted for, the results still indicate a large difference between the effective atmospheric transmittance and the atmospheric transmittance appropriate for continuum emission. This large difference can result only from the high degree of line correlation that exists between the hot H2O/CO2 emission spectrum and the cool H2O/CO2 atmospheric absorption spectrum. (GRA)

**5825** (N—75-26557/9ST) **Relative concentration of water vapor in the mesosphere of the arctic latitudes and mid-latitudes of the USSR as measured by radiofrequency mass spectrometers.** Byuro, E.D.; Martynkevich, G.M. Jun 1975. Translated from pp 25-36 of Tr., Nauchn. Soveshchanie po Mezosfernym Oblakam, Riga, 1970. (NASA-TT-F—16413). 17p. NTIS $3.25.

Rocket-borne radio frequency mass spectrometers were used to study the neutral composition of the thermosphere over arctic and mid-latitude regions of the U.S.S.R. during the period from October, 1966 to March, 1968. The measured concentrations of atomic hydrogen were from 2.5 to 20 times larger than predicted by existing models. The concentration of atomic hydrogen at the altitudes 100 to 160 km in the arctic was much larger than in the mid-latitude regions. Layers of increased water vapor content were observed over both the arctic and mid-latitude regions. There is evidence to suppose that water vapor and oxygen-hydrogen complexes in the mesopause are formed by the action of solar wind. (Author) (GRA)

### EFFECTS OF NUCLEAR DETONATIONS

**5826** **A study of electron spectra in the inner belt.** West, H.I. Jr.; Buck, R.M. (Lawrence Livermore Laboratory, University of California, Livermore, California 94550). *J. Geophys. Res.*; **81**: No. 25, 4696-4700(1 Sep 1976).

Comparisons are made between energetic electron spectra obtained in the inner belt(L=1.3-2.4) by the Ogo 5 satellite during 1968 and spectra acquired by other magnetic spectrometer experiments before and after the Starfish high-altitude nuclear detonation on July 9, 1962. The post-Starfish data show a continual decay at the higher energies (approximately-greater-than0.5 for 1962 to > or =1 MeV for 1968). Electrons of 2-MeV energy at L 1.4 showed a mean life of 1 year. By 1968, only a high-energy residual (>1 MeV) remained in the inner belt (L≅1.4). A pre-Starfish spectrum obtained in 1961 at L=1.38 is almost identical with out 1968 results for the same region. By 1968, Starfish electrons were no longer important as an aspect of inner-belt dynamics. (AIP)

### MAGNETOSPHERIC PHENOMENA

*REFER ALSO TO CITATION(S) 6320*

**5827** **Energetic protons of magnetospheric origin in the plasma sheet associated with substorms.** Hones, E.W. Jr.; Palmer, I.D.; Higbie, P.R. (Los Alamos Scienfitic Laboratory, Univeristy of California, Los Alamos, New Mexico 87545). *J. Geophys. Res.*; **81**: No. 22, 3866-3874(1 Aug 1976).

Energetic particle detectors on three of the Vela satellites provide three-dimensional measurements of fluxes of energetic electrons and protons and have revealed that after some substorms the expanding plasma sheet is populated with protons (0.5 MeV<E/sub p/<0.9 MeV) at flux levels above the intensity threshold of the detector, ~20 protons/$cm^2$ s sr MeV, which corresponds to one count per sampling interval. The proton flux characteristics are described.We conclude that the protons are energized within the magnetosphere in the substorm process and that the flux anisotropy is the consequence of a gradient in the proton density directed generally earthward and equatorward. The peak proton flux during any individual proton event tends to be directed perpendicular to the radius vector from the earth to the Vela satellite, suggesting that the magnetic field in the recovering plasma sheet lies more nearly in magnetic meridian planes than it is shown to do in published models based on magnetic field measurements. (AIP)

**5828** **The skylab barium plasma injection experiments 1. Convection observations.** Wescott, E.M.; Stenbaek-Nielsen, H.C.; Davis, T.N.; Peek, H.M. (Geophysical Institute, Univeristy of Alaska, Fairbanks, Alaska 99701). *J. Geophys. Res.*; **81**: No. 25, 4487-4494(1 Sep 1976).

Two barium plasma injection experiments were carried out during magnetically active periods in conjuction with the Skylan 3 mission. The high-explosive shaped charges were launched from Piker Flat near dawn on November 27 and December 4, 1973, UT. In both cases the AE index was near 400 $\gamma$, and extensive pulsating auroras covered the sky. The first experiment, Skylab Alpha, occurred in the waning phase of a 1000-$\gamma$ substorm, and the second, Skylab Beta, occurred in the expansive phase of an 800-$\gamma$

substorm. In both, the convective was generally magnetically eastward, with 100-km-level electric fields near 40 mV/m. However, in the Alpha experiment the observed orientation of the barium flux tube fitted with theoretical field lines having no parallel current, but the Beta flux tube orientation indicated a substantial upward parallel sheet current. The Skylab Alpha experiment was observed and photographed by the crew of Skylab 3 for 4 1/2 min. (AIP)

**5829 The Skylab barium plasma injection experiments 2. Evidence for a double layer.** Wescott, E.M.; Stenbaek-Nielsen, H.C.; Hallinan, T.J.; Davis, T.N.; Peek, H.M. (Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701). *J. Geophys. Res.*; 81: No. 25, 4495-4502(1 Sep 1976).

Television observations of a barium plasma flux tube extending from near 4500 km to near 10,000 km during a magnetic substorm and dawn sector auroral display indicated several interesting anomalous events. Beyond 5500 km there was a rapid increase in brightness accompanied by flux tube splitting and diffusion, leaving behind a truncated single flux tube. From the orientation of the flux tube compared with theoretical field models the presence of a substantial field-aligned current sheet is deduced. A suggested explanation of these phenomena is given in terms of a plasma potential double layer. (AIP)

## ATOMIC, MOLECULAR, AND CHEMICAL PHYSICS

*REFER ALSO TO CITATION(S) 5501*

### BEAMS AND THEIR REACTIONS

*REFER ALSO TO CITATION(S) 5320, 6361*

**5830 Pulsed gas target for ion charge exchange.** Bezlyudnyi, S.V.; Berezovskii, E.L.; Kislyakov, A.I.; Khdoleev, A.V. (Ioffe Inst. of Physics and Tech., Leningrad). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 410-411(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 749-752(1975).

The efficiency of the charge exchange of $H^+$ and $He^+$ ions in a pulsed hydrogen target shaped by a gaseous delay line has been measured at energies from 4 to 16 keV. The pumping process is modeled by means of electric circuits in order to determine the profile of the gas density along the target axis. At the optimum target density the efficiency of $H^+$ charge exchange is 70 to 80 percent and nearly independent of the energy, while the efficiency for $He^+$ charge exchange increases from 15 to 50 percent with increasing energy. These values are 5 to 7 times higher than the results obtained with steady-state gas target under analogous conditions.

**5831 Experimental investigation of the focusing cone of the "Tonus" electron beam.** Grigor'ev, V.P.; Remnev, G.E.; Ryabchikov, A.I.; Usov, Yu.I.; Shulaev, N.S. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 4, 159(Apr 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 335-337(12 Apr 1975).

A conical focusing mechanism for the Tonus accelerator consisting of a metal cone filled with neutral gas into which the electron beam is injected is described. The conical focusing mechanism is attributed to the fact that the gas breakdown time increases along the cone, which leads to a decrease in the inverse current along the longitudinal coordinate and to the appearance of a "frozen-in" focusing magnetic field. 2 figures, 5 references. (GHT)

**5832 Evaluation of a $LaB_6$ cathode electron gun.** Verhoeven, J.D.; Gibson, E.D. (Ames Lab., Iowa (USA)). *J. Phys., E* (*London*); 9: No. 1, 65-69(Jan 1976).

The brightness of the lanthanum hexaboride, $LaB_6$, cathode electron gun of the Stereoscan S-4 scanning electron microscope has been evaluated. This gun is an indirectly heated Broers type of $LaB_6$ gun design, and the several variables which affect its brightness have been evaluated using a cage device for the brightness measurements. The results indicate that when proper operating conditions are employed the $LaB_6$ brightnesses are of the order of 15 to 20 times that of tungsten operated at 40 h life conditions, and that single crystal cathodes are more reliable for producing high brightnesses.

**5833 Kinetic energy of ions formed in surface ionization. II. Ionization of atomic and molecular beams.** Sumin, L.V. (All-Union Scientific-Research Institute of Mineral Ores, Moscow). *Sov. Phys. - Tech. Phys.* (*Engl. Transl.*); 21: No. 3, 303-307(Mar 1976).

The velocity distribution is used to study the surface ionization of atomic beams of silver and lead; molecular beams of the chlorides of sodium, calcium, manganese, iron, cobalt, copper, tin, and barium; silver nitrate; and lead sulfide, fluoride, and iodide. In all cases the kinetic energies of the atomic metal ions correspond to the ionizer temperature within the experimental error of 20—30degree. Because of the low intensity, the velocity-projection distributions of the ions of more complicated composition can only be obtained in certain cases: $Na_2Cl^+$, $CaCl^+$, $BaCl^+$, $SnCl^+$, and $PbI^+$. The kinetic energies of these ions also correspond to the ionizer temperature, except in the cases of $SnCl^+$ and $PbI^+$, for which there is an energy deficit equivalent to several hundred degrees. The relative intensity and the angular distribution of the $PbI^+$ ions are governed by the ionizer material. In ionization on oxidized tungsten there are no deviations from equilibrium. (AIP)

**5834 Quality of ion collimation from a plasma.** Grishin, S.D.; Kuzovlev, V.F.; Ogorodnikov, S.N.; Orlov, R.V. *Sov. Phys. - Tech. Phys.* (*Engl. Transl.*); 21: No. 3, 350-351(Mar 1976).

A method is proposed for determining experimentally quality of the collimation of an ion beam extracted from a plasma by an ion-optical system. The method is applied to the beam taken from an argon plasma. (AIP)

**5835 Product magnetic deflection slotted disk velocity analysis molecular beams kinetics: Li+$Cl_2$, $Br_2$, and ICl.** Sholeen, C.M.; Gundel, L.A.; Herm, R.R. (Materials and Molecular Research Division, Lawrence Berkeley Laboratory and Department of Chemistry, University of California, Berkeley, California 94720). *J. Chem. Phys.*; 65: No. 8, 3223-3232(15 Oct 1976).

An inhomogeneous deflecting magnet and slotted disk velocity analyzer combination has been used to deflect aside nonreactively scattered Li atoms and thereby measure velocity distributions of LiBr and LiCl reactively scattered from crossed thermal beams of Li and $Br_2$ or $Cl_2$. Transformation of these data into the center-of-mass coordinate system provides contour maps of the differential reactive cross sections which indicate that the Li+$Br_2$ and the Li+$Cl_2$ reactions have the following features in common: (a) The reaction mechanisms are direct; (b) The product angular distributions are broad although foward scattering is preferred (i.e., LiX scattered in the direction of the Li velocity); (c) Small product recoil energies are most probable but the product recoil energy distributions have a long tail. There is a strong coupling of the product recoil angle and energy distributions for Li+$Cl_2$yieldsLiCl+Cl with forward scattering favoring higher product recoil energy; however, this coupling phenomenon is weak or nonexistent for the Li+$Br_2$yieldsLiBr+Br reaction. Semiquantitative observations are also presented for the Li+HCl reaction. These results are discussed in relation to previous experimental and theoretical work on the reactions of alkali atoms with halogen molecules. (AIP)

### ATOMIC AND MOLECULAR PROPERTIES

**5836 Photoionization.** Berkowitz, J. (Argonne National Lab., IL). pp 188-204 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

A review of photoionization processes is presented. Topics covered include autoionization in atomic gases, autoionization and pre-dissociation in molecules, the variation of total and partial cross section with photon energy, and partial cross sections and mass spectra. 16 figures, 18 references (GHT)

**5837 Possibility of excluding the continuous spectrum from the calculation of electron states of the molecular hydrogen ion 2: Dependence of polarizability on internuclear distance.** Sherstyuk, A.I.; Yakovleva, N.S. *Opt. Spectrosc.* (*USSR*) (*Engl. Transl.*); 40: No. 6, 560-562(Jun 1976).

The Green's function for the problem of two Coulomb force-centers, expanded as a complete set of Sturm functions with a purely discrete spectrum, is used to calculate the polarizability of the $H_2^+$ ion for different internuclear distances R. Results of the calculations confirm the rapid convergence of the Sturm expansions for all values of R. Values of the polarizability found for the equilbrium internuclear distance are compared with published values obtained by variational calculations. (AIP)

**5838 Absolute oscillator strengths for chromium and the chromium solar abundance.** Bieniewski, T.M. (Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico). *Astrophys. J.*; 208: No. 1, 228-236(15 Aug 1976).

Using the method of total absorption for weak lines on the linear part of the curve of growth, we measured absolute oscillator strengths for the ultraviolet (3600 A) transitions $a^7S_3$-$y^7p^o_3$/sub ./$_3$/sub ./$_4$ and for the violet (4275 A) transitions $a^7S_3$-$z^7P^o_3$/sub ./$_3$/sub ./$_4$. The oscillator strengths measured by total absorption

agree well with other measurements made by the lifetime, beam-foil, and hook methods. An absolute scale was established for several extensive compilations of oscillator strengths for chromium transitions with lower level energy, 0.94 eV< or =chi/sub l/< or =1.03 eV. Application of this absolute scale to several calculations of the solar chromium abundance resulted in the best value: $\log_{10}$(N/sub cr//N/sub H/) =5.31. (AIP)

**5839 Relativistic energy levels and bonding in actinide hexafluorides.** Koelling, D.D.; Ellis, D.E.; Bartlett, R.J. (Argonne National Laboratory, Argonne, Illinois 60439). *J. Chem. Phys.*; 65: No. 8, 3331-3340(15 Oct 1976).

A fully relativistic self-consistent Dirac—Slater model has been used to calculate one-electron energy levels and charge distributions for $UF_6$, $NpF_6$, and $PuF_6$. Analysis of ground state charge densities reveals 5f/sub n/ populations similar to free atom states; we are able to distinguish between metal—ligand bonding levels and the optically active levels described by crystal field theory. Ultraviolet and optical excitations, as well as ionziation energies, are calculated using an approximate transition state procedure and found to be in reasonable agreement with experiment. The Coulomb correlation integral appearing in the determination of the nature of 5f orbitals in solids is discussed on the basis of the systematics observed in our transition state calculations. (AIP)

## COLLISION PHENOMENA

*REFER ALSO TO CITATION(S) 5487, 6093*

**5840** (UCRL—52082) **Incoherent scattering of gamma rays by K-shell electrons.** Spitale, G.C.; Bloom, S.D. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 12 May 1976. Contract W-7405-ENG-48. 31p. Dep. NTIS $4.00.

Differential cross sections for incoherent scattering by K-shell electrons were measured, using coincidence techniques, for incident photons having energies of 662 keV, 320 keV, and 145 keV. The spectral distributions of the scattered photons emerging at scattering angles from 20° to about 140° are reported. Target materials were iron, tin, holmium, and gold at 320 keV; tin and gold at 662 keV; and iron and tin at 145 keV. A typical energy spectrum consists of a scattered peak that is much narrower than would be expected from the bound state electron motion. The peak also, typically, reaches a broad maximum width for scattering angles between 45° and 60°. Rather than monotonically increasing with atomic number the peak width reaches a broad maximum, generally, between Z = 50 and Z = 67, and then decreases with increasing atomic number. No Compton defect appears in any of the peaks to within +- 20 keV. A discussion of the expected magnitude of the Compton defect is included. The peak is superimposed on a continuum that diverges at the low end of the scattered photon spectrum for the following cases: gold, holmium, and tin targets for 320-keV incident photons; gold and possibly tin targets for 662-keV photons incident. This infrared divergence is expected on theoretical grounds and has been predicted. It is very nearly isotropic.

**5841 Introduction to the symposium on the basic physics of the interactions of radiation with matter.** Inokuti, M. (Argonne National Lab., IL). pp 184-187 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

The introductory comments include a brief summary of each paper presented in the symposium, as well as comments on the life of Professor Robert L. Platzman. Topics covered in the symposium include: photoionization; electron energy deposition in matter at the molecular level; secondary electron spectra; ionization by energy transfer from excited species; ionization by interpenetration of electron shells; spontaneous breakup of gaseous ions; and ion-molecule reactions. (GHT)

**5842 Electron energy deposition in matter at the molecular level.** van der Wiel, M.J. (FOM Inst. for Atomic and Molecular Physics, Amsterdam). pp 205-218 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

Some aspects of the study of superexcited states by means of electron impact are reviewed. Several examples of superexcited states given are: Rydberg states, which are part of series converging on the various IP's of a molecule (single valence electron excitation); multiply excited states (multiple valence electron excitation); and inner shell vacancy states (inner electron transitions to bound or continuum states). 8 figures, 49 references (GHT)

**5843 Ionization by energy transfer from excited species.** Niehaus, A. (Univ., Freiburg i. B.). pp 227-241 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

The different types of ionization processes occurring in thermal collision, by transfer of electronic excitation are discussed, and an outline is given of the present understanding of their mechanisms. 2 tables, 9 figs, 45 refs (GHT)

**5844 Ionization by interpenetration of electron shells.** Smith, F.T.; Salop, A. (Stanford Research Inst., Menlo Park, CA). pp 242-254 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

A review is given of the ionization and excitation processes associated with collisions in which the partners get so close that various atomic shells interpenetrate. Topics covered are: Coulomb ionization; charge transfer ionization; shell interpenetration phenomena; differential inelastic energy loss measurements; Fano-Lichten model; coupling mechanisms; energy thresholds for inner-shell excitation; and energy deposition in inner-shell processes. 10 figs, 20 refs (GHT)

**5845 Spontaneous break-up of gaseous ions.** Ottinger, C. (Max-Planck-Institut fuer Stromungsforschung, Goettingen, Ger.). pp 255-275 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

The study of delayed spontaneous dissociations is reviewed. Its bearing ranges from quantum mechanical and statistical problems in theoretical unimolecular kinetics to analytical organic mass spectrometry and computerized apparatus. Areas reviewed are: instrumental configurations; chemical applications; energetics; and kinetics. 14 figs, 68 refs (GHT)

**5846 Study of the momentum distribution of K-electrons of carbon and oxygen by quasielastic (e,2e) knockout of electrons by electrons.** Krasil'nikova, N.A.; Persiantseva, I.M. (Nuclear Physics Research Inst., Moscow). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 3, 127-128(Mar 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 266-269(26 Mar 1975).

An experimental study of the momentum distribution of the electrons of the internal shells of light atoms of carbon and oxygen is reported. Inasmuch as the binding energies of these levels amount to several hundred electron volts, it follows that to probe these shells it suffices to have an energy resolution $\Delta E$ approximately 100 eV. The use of solid targets permits a sufficiently rapid coincidence counting rate, in spite of the smallness of the cross section of the (e,2e) process (approximately $10^{-22}$ cm²/eV-sr²).

**5847 Bremsstrahlung of electrons from ions with allowance for screening.** Zhdanov, D.P.; Chibisov, M.I. (I. V. Kurchatov Institute of Atomic Energy). *JETP Lett.* (*USSR*) (*Engl. Transl.*); 23: No. 4, 10-13(20 Feb 1976).

Exact numerical calculations were performed of the bremsstrahlung from a multielectron ion with allowance for screening, using a Thomas-Fermi potential. The results lead to the conclusion that the methods previously developed for calculating bremsstrahlung {V.D. Kirillov et al., Fiz. Plazmy 1, 218 (1975) [Sov. J. Plasma Phys. 1, 117 (1975)]; V. I. Gervids and V. I. Kogan, Pis'ma Zh. Eksp. Teor. Fiz. 22, 308 (1975) [JETP Lett. 22, 142 (1975)]} are accurate. (AIP)

**5848 Attachment of slow electrons to hexafluorobenzene.** Gant, K.S.; Christophorou, L.G. (Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830). *J. Chem. Phys.*; 65: No. 8, 2977-2981(15 Oct 1976).

Slow (approximately-less-than 3 eV) electrons attach to hexafluorobenzene ($C_6F_6$) nondissociatively with large cross sections via two distinct processes, one at ~0.0 eV and another peaking at 0.73 eV. The absolute rates and cross sections have been determined as a function of electron energy for both processes and are reported. At 0.03 and 0.73 eV the cross sections are 1.23 x

$10^{-14}$ and 8.04 x $10^{-16}$ $cm^3$, respectively; the thermal (T=297degreeK) value of the attachment rate is 3.3 x $10^9$ $sec^{-1}$ $torr^{-1}$(=1.02 x $10^{-7}$ $sec^{-1}$ $molecule^{-1}$ $cm^3$). The lifetime tau of $C_6F_6^{-*}$ at ~0.0 eV is ~12 μsec, but at 0.73 eV it is much shorter, $10^{-8}$approximately-less-thantau<$10^{-6}$ sec. The ~0.0 eV process is associated with electron capture into the degenerate $\pi_4$ and $\pi_5$ molecular orbitals and is ascribed to the configurations $\pi^2_1\pi^2_2\pi^2_3\pi^1_4$ and $\pi^2_1\pi^2_2\pi^2_3\pi^1_5$, while the 0.73 eV process is associated with electron capture into the $\pi_6$ orbital and is ascribed to the configuration $\pi^2_1\pi^2_2\pi^2_3\pi^1_6$. For both $C_6H_6$ and $C_6F_6$ a relationship is shown to exist between the ionization energies of the occupied $\pi_1$ and $\pi_2$, $\pi_3$ orbitals and the position of the negative ion (shape) resonances associated with the unoccupied $\pi_4$, $\pi_5$, and $\pi_6$ orbitals. The observed large attachment rates for $C_6F_6$ extending from thermal energies to approximately-greater-than3 eV recommend it as a potential "additive" in high-voltage multicomponent gaseous insulators. (AIP)

### ATOMIC AND MOLECULAR THEORY

*REFER ALSO TO CITATION(S) 5845*

**5849** (N—75-24439) **Difference equation for superradiance.** Lee, C.T. (Alabama A and M Univ., Normal (USA). Dept. of Physics and Mathematics). 1974. 10p. (NASA-CR—142875). NTIS $3.25.

The evolution of a completely excited system of N two-level atoms, distributed over a large region and interacting with all modes of radiation field, is studied. The distinction between r-conserving (RC) and r-nonconserving (RNC) processes is emphasized. Considering the number of photons emitted as the discrete independent variable, the evolution is described by a partial difference equation. Numerical solution of this equation shows the transition from RNC dominance at the beginning to RC dominance later. This is also a transition from incoherent to coherent emission of radiation. (Author) (GRA)

**5850** (SAND—76-0374) **Auger transition rate including magnetic quantum numbers.** McGuire, E.J. (Sandia Labs., Albuquerque, N.Mex. (USA)). Aug 1976. Contract E(29-1)-789. 18p. Dep. NTIS $3.50.

Explicit expressions including magnetic quantum numbers are obtained for the Auger transition rate for a single inner shell vacancy. The tabulated results are for cases where the angular momentum of the initial state inner-shell vacancy is 0 or 1, while the initial state electron angular momentum can be 0, 1, or 2.

## GENERAL FLUID DYNAMICS

*REFER ALSO TO CITATION(S) 5310*

**5851** (UCRL—77651) **SLIC (simple line interface calculation).** Noh, W.F.; Woodward, P. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 23 Aug 1976. Contract W-7405-Eng-48. 13p. (CONF-760664—2). Dep. NTIS $3.50.

From 5. international conference on numerical methods in fluid dynamics; Enschede, Netherlands (28 Jun 1976).

SLIC is an alternating-direction method for the geometric approximation of fluid interfaces. It may be used in one, two, or three space dimensions, and it is characterized by the following features: Fluid surfaces are represented locally for each mixed-fluid zone, and these surfaces are defined as a composition of one-space-dimensional components, one for each coordinate direction. These one-dimensional components are composed entirely of straight lines, either perpendicular to or parallel to that coordinate direction. The one-dimensional surface approximations for a mixed fluid cell are completely determined by testing whether or not the various fluids in the mixed cell are present or absent in the zone just to the left and to the right in the coordinate direction under consideration. Because of the completely one-dimensional nature of the SLIC interface description, it is relatively easy to advance the fluid surfaces correctly in time. With the SLIC fluid-surface definitions, it should be possible to incorporate any one-space-dimensional method for advancing contact discontinuities. This makes SLIC very practical for the numerical solution of fluid dynamical problems.

**5852** **Pressure distribution due to normal impinging plane and axisymmetric jets.** Parameswaran, V. (Fluor Pioneer Inc., Chicago). *Trans. Am. Nucl. Soc.*; 23: 182-183(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## MAGNETOHYDRODYNAMICS

**5853** (AD-A—011684) **Discontinuous magnetofluidynamic flows. Final scientific report, 1972—3.** Geffen, N. (Tel Aviv Univ. (Israel)). 1975. 103p. NTIS $5.25.

Investigations of Magnetofluiddynamic flows with shock waves have been carried out by analytical numerical and graphical methods, with a simple experiment added to demonstrate an analogy between plasma and magnetohydraulic flows. Solutions are given for flows around bodies and in given regions of the type prevalent in space research and technology; in hypersonic flight, where the fluid adjacent to the craft gets ionized; and in plasma configurations considered for thermonuclear fusion, e.g. theta-pinches, the Tokomak. The conducting-liquid analysis and experiments are applicable to MHD pumps and motors and to the liquid-sodium cooling system for atomic breeder reactors. (GRA)

## SUPERFLUIDITY

*REFER ALSO TO CITATION(S) 5539, 5947, 5951, 5962*

**5854** **Longitudinal NMR frequencies in superfluid $^3$He.** Ahonen, A.I.; Krusius, M.; Paalanen, M.A. (Low Temperature Lab., Helsinki Univ. of Technology, Espoo, Finland). pp 107-110 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The phenomenon of longitudinal NMR is known to occur in both the A and B phases of superfluid $^3$He. This work is part of recent efforts to investigate with more extensive measurements the properties of Δ(T), the gap parameter of the condensate. The $^3$He specimen was located in a copper chamber and could be cooled with a nuclear demagnetization refrigerator down to 0.7 mK. The temperature was determined by pulsed NMR from the nuclear susceptibility of platinum powder immersed in liquid $^3$He. The $^3$He NMR pick-up coil, located inside the sample cell, was wound around a stack of 0.13 mm thick mylar foils evenly spaced 0.38 mm apart.

**5855** **Non-turbulent breakdown of superfluidity in He II.** Allum, D.R.; McClintock, P.V.E.; Phillips, A. (Lancaster Univ. (UK)). pp 248-251 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

It was discovered recently that, contrary to the inferences drawn from earlier experiments in weak electric fields, the drag experienced by a negative ion travelling at a supercritical velocity through pressurised HeII is very much smaller than predicted theoretically. Using the same apparatus based on a field emission ion source, the range of the measurements has been extended and their precision improved.

**5856** **Kapitza resistance measurements between $^3$He and silver at very low temperatures.** Andres, K.; Sprenger, W.O. (Bell Labs., Murray Hill, N.J. (USA)). pp 123-126 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The Kapitza conductance was measured between $^3$He and 'pure' silver (magnetic impurity content approximately 2ppm) as well as 'dirty' silver (strongly paramagnetic) and a $T^3$ dependence was found down to around 13 mK and approximately $T^1$ dependence down to 1.5 mK with no difference between the two silver samples. This suggests that alternative mechanisms of energy transport from the conduction electrons to the $^3$He may have to be considered.

**5857** **Specific heat of $^3$He superfluids in several magnetic fields.** Archie, C.N.; Halperin, W.P.; Rasmussen, F.B.; Gould, C.M.; Alvesalo, T.A.; Richardson, R.C. (Cornell Univ., Ithaca, N.Y. (USA). Dept. of Physics). pp 96-99 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Measurements of specific heat in the A, $A_1$, and B phases of $^3$He have been performed along the melting curve in magnetic fields up to 8.4 kOe. Use was made of the suppression of the B transition by magnetic field to extend the available temperature range of the A phase to T/T/sub c/ = .49. From these measure-

ments the jumps in specific heat, Δc/sub A/, Δc/sub A1/, and Δc/sub A2/ at the temperatures T/sub A/, T/sub A1/, and T/sub A2/, were determined.

**5858 Rotons and multi-rotons.** Baeriswyl, D. pp 161-164 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The excitation spectrum of superfluid $He^4$ consists essentially of three parts: the long-wavelength phonon region, the short-wavelength free particle spectrum and in the intermediate range the roton minimum. There have been many attempts to deduce this spectrum from a microscopic theory. The present theory represents the dynamic structure factor as a series of equally spaced well-defined branches at the location of the roton minimum.

**5859 Heat pulse experiments to study the evaporation of superfluid He.** Balibar, S. (Ecole Normale Superieure, 75 - Paris (France). Groupe de Physique des Solides). pp 431-434 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Atoms evaporated by phonons and atoms evaporated by rotons are separated using the heat pulse technique. The experiment is performed at .45K. The heater and bolometric detector are metal films deposited on a ceramic substrate.

**5860 Transport phenomena in superfluid $^3He$ near the transition temperature.** Bhattacharyya, P.; Pethick, C.J. (Illinois Univ., Urbana (USA). Dept. of Physics); Smith, H. (Copenhagen Univ. (Denmark). H.C. Oersted Inst.). pp 9-12 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A Boltzmann equation is derived for describing kinetic phenomena in superfluid Fermi liquids near the transition temperature Tsub(c) and is used to calculate the viscosity of the normal component, the collisional attenuation of zero sound and the rate of magnetic relaxation processes, to first order in the superfluid gap. The calculations fully take into account the character of the excitations in the superfluid.

**5861 Excitations observed in thin $^4He$ films.** Bishop, D.J.; Parpia, J.M.; Reppy, J.D. (Cornell Univ., Ithaca, N.Y. (USA). Lab. of Atomic and Solid State Physics). pp 380-383 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Using a technique developed by Hall and Reppy third sound has been used to investigate thin $^4He$ films adsorbed on Vycor glass. The data support the idea of a 'frozen out layer' of $^4He$ which forms a favorable substrate for superflow and the existence of phonon and roton excitations in the thin $^4He$ films, but with a roton gap changed by the influence of the walls.

**5862 Viscosity and anomalous modes of liquid $^4He$ in an oscillating cylinder.** Biskeborn, R.; Guernsey, R.W. Jr. (Columbia Univ., New York (USA). Columbia Radiation Lab.). pp 291-293 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The damping has been measured on an oscillating linen bakelite cylinder (0.7 cm high, 2.30 cm radius) filled with liquid $^4He$ with a precision of approximately 0.05% from 1.2 to 4.2 Kelvin. The damping increases with temperature approximately as $\sqrt{\text{etarho}}$ (where rho = relevant fluid density, eta = viscosity) but in addition shows anomalous peaks below Tsub(lambda). Using the same apparatus the damping on an identical cylinder but now made of copper was measured. In this case the damping shows no peaks. The data suggest that the anomalous damping could be due to the liquid inside the bakelite. Further investigation of this phenomenon is in progress.

**5863 ac Josephson Effect in superfluid helium.** Biswas, A.C. (Tata Inst. of Fundamental Research, Bombay (India)). pp 135-138 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The microscopic formulation of Quantum Hydrodynamics developed by the author and his collaborators at TIFR is used to analyse the problem of the ac Josephson effect in He II. It is concluded that an ac Josephson current should be observable in He-II well below $1^oK$.

**5864 Phenomena in $^3He/^4He$ solutions near the solid surface.** Borovikov, A.P.; Peshkov, V.P. (AN SSSR, Moscow. Inst. Fizicheskikh Problem). pp 352-355 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The behaviour of shear waves in liquid $^3He$ was experimentally studied at the frequencies 15 and 25 MHz within the temperature range 7 mK - 800 mK. At temperatures T<1 K even very small quantities of $^4He$ in $^3He$ lead to the appearance of a superfluid film of $^4He$ on the solid surface and it causes a great decrease in the interaction of $^3He$ on the solid surface. A slip phenomenon is observed, i.e. the friction between $^3He$ and the solid surface decreases by orders of magnitude at low temperatures.

**5865 Frequency shifts in pulsed NMR for the A- and B-phases of superfluid $^3He$.** Brinkman, W.F.; Smith, H. (Bell Labs., Murray Hill, N.J. (USA)). pp 45-48 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The results of the recent pulsed NMR experiments by Osheroff and Corruccini have been shown by the present authors to be understood rather simply in terms of solutions to the nonlinear resonance equations put forward by Leggett. The experiments have been done in the A- and B-phases of superfluid $^3He$ at magnetic fields high enough that the dipole interaction may be treated as a perturbation in the resonance equations. The rather remarkable agreement between theory and experiment makes it possible in the B-phase to measure directly the angle $\text{theta}_d = \cos^{-1}(-1/4)$ characterizing the Balian-Werthamer state.

**5866 Shear viscosity of $^4He$ near the superfluid transition.** Bruschi, L.; Mazzi, G.; Santini, M.; Torzo, G. (Padua Univ. (Italy). Istituto di Fisica). pp 294-296 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The shear viscosity eta of $^4He$ has been measured at saturated vapour pressure by several authors in the range of reduced temperature $10^{-4} <$ epsilon $< 10^{-2}$. The authors performed measurements of eta on both sides of the lamda transition for $10^{-6} <$ or approximately = epsilon < or approximately = $10^{-2}$, using a vibrating wire viscometer. According to the results the viscosity eta is finite and continuous at the transition. The first derivative deta/dT exhibits a strong discontinuity at T/sub lambda/, and a weak divergence at the superfluid side of the transition.

**5867 About the damping of the He II oscillations.** Calvani, P.; Maraviglia, B. (Rome Univ. (Italy). Istituto di Fisica). pp 403-406 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Experimental data taken in a much more isothermal condition than all the others previously reported are presented for the damping of He II film oscillations. Level oscillations in a copper beaker with a cross-sectional area of 7.1 $cm^2$ are detected by measuring the current between a $^{210}Po$ source and a collector.

**5868 Critical velocities in $^3He-^4He$ mixtures.** Carey, R.; Pobell, F. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany). Inst. fuer Festkoerperforschung). pp 348-351 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The method of Kojima et al. of Doppler-shifted fourth sound has been used to investigate persistent currents and critical velocities in $^4He$ and in an 11% $^3He-^4He$ mixture. The fourth sound resonator is a torus of mean diameter D=8.0 cm and cross-section 0.4 cm x 0.4 cm, and is filled with $Al_2O_3$ powder.

**5869 Hydrodynamics of rotons below $1^oK$.** Castaing, B. (Ecole Normale Superieure, 75 - Paris (France). Groupe de Physique des Solides). pp 287-290 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In superfluid helium above 1°K a heat pulse propagates as a second sound, hydrodynamic regime of phonons and rotons. At low temperature, below 0.6°K, the phonons mean free path is large, 1mm or more and the heat pulse propagates ballistically at about the first sound velocity. Recently, Dynes, Narayanamurti and Andres observed that at 24 bars a new pulse of lower velocity appears, which they associate with the propagation of interacting rotons. The observed velocity, 16 m/s, did not correspond to a roton second sound velocity. Developing their experiment, it is found that this pulse has a very broad lineshape, and in order to assign a velocity to this new pulse, a theory of the lineshape has to be developed.

**5870 Observations on the isothermal flow of superfluid helium through a small orifice.** Chai, T.Y.; Khorana, B.M. (Notre Dame Univ., Ind. (USA). Dept. of Physics). pp 211-214 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A study of the v-ΔZ characteristics of a system of two superfluid helium samples coupled to each other through a small orifice in order to explore further the analogies in the coherence properties of coupled superfluids and superconductors is reported. Here v is the flow velocity of liquid helium through the orifice, and ΔZ is the liquid level difference between the two helium samples. Since the flow velocity v is proportional to the mass current through the orifice and the level difference ΔZ is proportional to the potential energy difference in the isothermal flow case, a study of v-ΔZ characteristics in this case is analogous to a study of the current-voltage (I-V) characteristics of coupled superconductors.

**5871 Helium interface mode excitation spectrum: the evidence, the form and implications.** Chester, M. (Freie Univ. Berlin (F.R. Germany). Inst. fuer Theoretische Physik); Eytel, L. (California Univ., Los Angeles (USA). Dept. of Physics). pp 376-379 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A host of experiments on the superfluidity of thin films of liquid helium have been reported recently. There is always a superfluid deficit, i.e. less superfluid appears to be present than one expects if bulk behavior obtained in these films. This deficit, as a function of film thickness, becomes constant in the limit of large film thicknesses. The temperature dependence of the thick-film-limit-deficit has been quantitatively ascertained by experiments. The theoretical implications of these results are discussed.

**5872 Spin-lattice relaxation in superfluid $^3$He.** Corruccini, L.R. (California Univ., Davis (USA). Dept. of Physics); Osheroff, D.D. (Bell Telephone Labs., Inc., Murray Hill, N.J. (USA)). pp 111-114 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Measurements of very fast and unusual longitudinal spin relaxation in superfluid $^3$He are reported. Measurements were made at melting pressures in a $He^3$ compression cell using both pulsed and continuous-wave NMR techniques, and indicate that new and apparently unique relaxation mechanisms are present below T/sub c/.

**5873 Orbit waves in the ABM phase of superfluid $^3$He.** Cross, M.C.; Anderson, P.W. (Cambridge Univ. (UK). Cavendish Lab.). pp 29-32 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Orbit waves are the Goldstone Boson mode of the broken rotational symmetry of the A phase of $^3$He. In the absence of the nuclear dipole interaction they would simply be an oscillation of l, the direction in k-space of the point nodes of the gap in the excitation energy. First the case of the no dipole interaction is considered and the effects of this are included later. It is shown that over the range of temperatures for which the A phase is usually stable orbit waves are highly overdamped.

**5874 $^3$He transport in the superfluid helium film.** Crum, D.B.; Edwards, D.O.; Sarwinski, R.E. (Ohio State Univ., Columbus (USA). Dept. of Physics). pp 423-426 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In a conventional 'film-flow' experiment using a cylindrical beaker the transport of the adsorbed $^3$He over the surface of the saturated helium film has been observed. This flow is impeded by the transfer of momentum from the surface to the substrate by $^3$He quasiparticles in the body of the film. It is believed that the results obtained for the scattering of $^3$He quasiparticles by the film's surface will also be valid for the bulk since surface measurements of the film thickness have shown that the $^4$He chemical potential at the surface of the film $\mu_4(P,T,X)$ is the same as in the bulk liquid. A flow impedance connected with absorption and emission of bulk quasiparticles into and out of the surface has also been observed.

**5875 Measurement of critical velocities for vortex creation: the attainment of the equilibrium state in rotating helium.** DeConde, K.; Packard, R.E. (California Univ., Berkeley (USA). Dept. of Physics). pp 264-267 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A process has been found which seems to put a sample of rotating He II into a true equilibrium state thus enabling the authors to quantitatively verify some of the equilibrium predictions of critical velocities. The basic process has been used previously by others and simply consists of initially rotating the liquid above the lambda point until internal mechanical equilibrium exists and then subsequently cooling the steadily rotating sample to below T/sub lambda/.

**5876 Influence of normal fluid on the quantized vortices of He II and vortices in the wake of bubbles in a classical fluid.** Deroyon, J.P.; Deroyon, M.J.; Le Ray, M. (Lab. d'Hydrodynamique Superfluide, Centre Universitaire de Valenciennes, France). pp 279-282 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Vortices may be studied in HeII by second sound attenuation measurements. So, in the case of vertical rotation with vertical or horizontal counterflow, or with horizontal superflow, and in the case of a vertical counterflow alone, the extra attenuation of second sound can be related to the quantized helical deformations of vortices. The vortices are described by the introduction of angular momentum quantum numbers l,m in the classical Snyder's law of attenuation in sin$^3$theta, according to the rules of quantization of the angular momentum observables ($L^2$ and Lsub(z)). Moreover, second sound analyses in presence of counterflow applied to the vortices revealed the characteristic Tkachenko vortex wave velocity s.

**5877 Escape rates of positive ions from vortex rings in liquid He-II.** van Dijk, J.D.P.; Wiebes, J.; de Jonge, B.R.; Kramers, H.C. (Rijksuniversiteit Leiden (Netherlands). Kamerlingh Onnes Lab.). pp 256-259 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Drift velocity data of positively charged vortex rings are used to calculate escape rates. For T > approximately 0.8 K these escape rates agree with the thermal activation theory. At lower temperatures another process appears to dominate the escape rate.

**5878 Velocity of surface sound in superfluid helium at very low temperatures.** Disatnik, Y. (Tel Aviv Univ. (Israel). Dept. of Physics and Astronomy). pp 427-430 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The expressions obtained for the velocity of surface sound in superfluid helium, at very low temperatures are described. These expressions are suitable for application in situations corresponding to different degrees of surface contamination by the $He^3$ impurities.

**5879 Specular reflection of $^4$He atoms at the liquid surface.** Edwards , D.O.; Fatouros, P.P.; Ihas, G.G.; Mrozinski, P.; Shen, S.Y.; Tam, C.P. (Ohio State Univ., Columbus (USA). Dept. of Physics). pp 435-438 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Measurements of the elastic scattering probability of low energy $^4$He atoms incident on the free surface of superfluid $^4$He are described. The probability of elastic scattering R(k, theta) was

measured as a function of the angle of incidence theta and the momentum hk/2$\pi$ of the incident atoms. The liquid helium surface was varied in temperature between 0.03 and 0.12K and no temperature dependence in R was observed. The experimental R(k, theta) is therefore characteristic of the ground state of the liquid and its surface.

**5880 Spin-diffusion and nuclear magnetic susceptibility of $He^3$ in liquid $He^3$-$He^4$ mixtures near the tricritical region.** Fenner, D.; Luszczynski, K. (Washington Univ., St. Louis, Mo. (USA). Dept. of Physics). pp 341-344 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The behaviour of spin-diffusion of $He^3$ in liquid $He^3$-$He^4$ mixtures in the tricritical region is not known and, so far, the question has not been treated in any detail. In the experiments to be reported here spin-diffusion of $He^3$ has been measured using pulsed NMR techniques. The results can be compared with other dynamical properties of liquid $He^3$-$He^4$ mixtures in this region. In addition, data on nuclear magnetic susceptibility of these mixtures have been obtained in an attempt to determine its behaviour in the neighbourhood of the tricritical point.

**5881 Order parameter and frictional effects on the transport conditions of Gorter-Mellink counterflow.** Frederking, T.H.K. (California Univ., Los Angeles (USA)); van Kempen, H.; Weenen, M.A.; Wyder, P. (Katholieke Universiteit Nijmegen (Netherlands)). pp 219-222 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Evidence for the existence of quantized vortex lines in He II from ion diagnostics probing micro-properties has raised related questions in the area of macro-phenomena (e.g. Gorter-Mellink (GM) transport). Examples are the possible influence of vortex lines on order parameter and liquid density, further, vortex bundle interaction (in eddies of bulk liquid) with shear viscosity dominated liquid domains at confining walls. Continuing a previous search for density effects attention is focussed on one particular question: Is it possible to express the flow response in terms of the order parameter and shear viscosity eta/sub n/ of the normal fluid. Continuum similarity concepts are considered and new counterflow data (zero net mass flow) obtained with the previous apparatus are reported.

**5882 Experiments with persistent currents in saturated films of superfluid helium.** Galkiewicz, R.K.; Hallock, R.B. (Massachusetts Univ., Amherst (USA)). pp 407-410 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Direct evidence for persistent currents in saturated films of superfluid helium has recently been presented. Prior to this several experiments had shown unexpected features which were subsequently shown to be consistent with the presence of persistent currents by the theoretical work of Campbell. The present work is an extension of earlier work and provides qualitative support for several of the characteristic film flow 'signatures' predicted by Campbell.

**5883 Third sound resonances and evidence for macroscopic mass flow in saturated film persistent current experiments.** Galkiewicz, R.K.; Telschow, K.L.; Hallock, R.B. (Massachusetts Univ., Amherst (USA)). pp 415-418 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Observations of third sound resonances on both static and moving saturated films of superfluid $^4$He are reported. Measurements of the attenuation of these resonances in the frequency range from 0.1 Hz to 1.0 Hz yield values substantially smaller than previously reported values linearly extrapolated to these frequencies. Shifts in the resonant frequencies caused by the presence of a persistent current in the apparatus support the conclusion that persistent mass flow was seen in the experiments of Galkiewicz and Hallock.

**5884 Measurements of the differential osmotic pressure of liquid $^3$He/$^4$He mixtures near the lambda curve and tricritical point.** Gearhart, C.A. Jr.; Zimmermann, W. Jr. (Minnesota Univ., Minneapolis (USA). Tate Lab. of Physics). pp 325-328 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Measurements have been made of the osmotic pressure difference $\Delta P$ which accompanies a small $^3$He mole fraction difference $\Delta x$ at constant absolute temperature T and $^4$He chemical potential $\mu_4$ in liquid $^3$He/$^4$He mixtures in the vicinity of the lambda curve and tricritical point near saturated vapor pressure. The purpose of these measurements was to determine (deltax/deltaΔ) /sub T,P/ in that region, where Δ is the difference $\mu_3$-$\mu_4$ between chemical potentials.

**5885 Motion of ions along vortices in He II.** Glaberson, W.I.; Ostermeier, R.M. (Rutgers--the State Univ., New Brunswick, N.J. (USA). Dept. of Physics). pp 260-263 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Measurements of the mobility of negative ions, trapped on vortex lines, along the vortex lines showed that 'trapped' ions experienced more drag, in motion through the liquid, than 'free' ions. Using a rotating $He^3$ refrigerator, these earlier measurements have been extended to lower temperatures and several new features have been observed which cannot easily be explained in terms of either previous theoretical approach.

**5886 Collective excitations in superfluid $^3$He.** Gongadze, A.D.; Gurgenishvili, G.E.; Kharadze, G.A. (AN Gruzinskoj SSR, Tbilisi. Inst. Fiziki). pp 21-24 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The technique of Larkin and Migdal has been adapted to investigate properties of superfluid Fermi systems with strong interaction between quasi-particles. Having formulated this method for a system with triplet pairing, the authors consider spin waves in isotropic B phase of liquid $^3$He.

**5887 Hydrodynamics of $^3$He in the quasi-isotropic B phase.** Graham, R.; Pleiner, H. (Essen Univ. (Gesamthochschule) (F.R. Germany)). pp 1-4 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The linearized hydrodynamics of $^3$He-B is derived from the eight global conservation laws ( mass (1), momentum (3), energy (1), spin (3) ) and the four broken symmetries ( gauge invariance (1), rotational invariance of spins against real space (3) ). These broken symmetries are present, if $^3$He-B is, indeed, a Balian Werthamer state, as assumed. The method of derivation is analogous to earlier hydrodynamic spin wave theories.

**5888 Field theories of excitations in superfluid helium.** Grest, G.S. (Rutgers--The State Univ., New Brunswick, N.J. (USA). Dept. of Physics); Rajagopal, A.K. (Indian Inst. of Science, Bangalore. Centre for Theoretical Studies). pp 139-142 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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A basic unity is sought in several microscopic theories, developed during the past three decades, which propose to describe the properties of superfluid liquid helium. It is shown that these field theoretic approaches may all be equivalent because they all stem from an underlying algebraic structure of the Bose field itself, but none seem to properly describe the experimentally measured energy and momentum distribution functions for liquid helium.

**5889 Nuclear magnetic resonance effects in low fields.** Gully, W.J.; Gould, C.M.; Richardson, R.C.; Lee, D.M. (Cornell Univ., Ithaca, N.Y. (USA). Lab. of Atomic and Solid State Physics). pp 104-106 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The longitudinal resonance has been studied in a parallel plate geometry in low magnetic fields and moderate electric fields. The apparatus consists of six sapphire plates with evaporated silver film electrodes on each face, spaced one millimeter apart in a block on which were wound two 'Helmholtz pair' copper coils. The assembly was placed in a Pomeranchuk cell in such a way that only vertical flow was possible.

**5890 Negative flow resistance leading to regular oscillations in the flow of He II.** de Haas, W.; van Beelen, H. (Rijksuniversiteit Leiden (Netherlands). Kamerlingh Onnes Lab.). pp 215-218 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The properties of adiabatic superfluid flow, driven by a set of displacers P through a superleak S with a glass capillary C (i.d.=216$\mu$m, l=8.84cm) in series, are investigated. At different values of the mass-flow velocity V/sub cap/ imposed by the displacers, and the transport velocity of the normal component V/sub n/ generated by the heater H, $\Delta Z=Z_2-Z_1$ and $\Delta T= T_2-T_1$ are measured after stationary flow has been established. Oscillations, which can be fully explained in terms of the behaviour during steady flow, are observed.

**5891 Phenomenological theory of superflow and orbital precession in $^3$He-A.** Hall, H.E. (Manchester Univ. (UK)). pp 33-36 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The object of this paper is to formulate the hydrodynamics of an axial superfluid in a way which avoids ambiguities in the definition of phase and brings out the analogies with ferromagnetism and nematic liquid crystals. The assumption that the order parameter has the structure appropriate to an axial l=1 state is made, namely that it factorizes into the product of a vector V in spin space and a complex vector $\Delta$ in ordinary space.

**5892 Method to study speed and attenuation of fourth sound at low frequencies in a long glass capillary.** Hartoog, A.; van Beelen, H.; de Bruyn Ouboter, R.; Taconis, K.W. (Rijksuniversiteit Leiden (Netherlands). Kamerlingh Onnes Lab.). pp 241-243 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Measurements are reported of speed and attenuation of fourth sound at low frequencies, generated in a well defined geometry, essentially a U-tube, formed by a 117 m long glass capillary (i.d.2r=170+-6$\mu$), wound into a spiral, filled with liquid helium. One of the legs can be moved up and down in a continuously adjustable frequency, in the range of 0.5-3.5Hz, thus imposing a periodic level difference. The level in the fixed leg is observed to remain at rest most of the time, except for special values of the driving frequency, corresponding with standing waves in the capillary. The speed of the wave is calculated from the length of the capillary and the frequency. One can calculate the damping coefficient from the rate of decrease of amplitude, observed after turning off the motor.

**5893 Trapping of persistent currents in superleaks.** Heiserman, J.; Rudnick, I. (California Univ., Los Angeles (USA). Dept. of Physics). pp 207-210 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Two sound modes can propagate in superfluid helium in an annular cavity: a modified second sound mode C(II) and an interpolated first-fourth sound mode C(14). Since both modes have components of first and second sound in the free region and fourth sound in the packed region, first, second or fourth sound transducers may be used to generate and detect both modes. Persistent currents were generated by two methods and the result of extensive measurements was that the C(14) mode shows considerable splitting and the C(II) mode shows no splitting, although peak broadening was observed.

**5894 Fluctuations from vortex-line turbulence in He II.** Hoch, H.; Busse, L.; Moss, F. (Missouri Univ., St. Louis (USA)). pp 275-278 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The authors have studied fluctuations of the vortex line density with both ion (IP) and second sound (SP) probes. Their results have shown that the distribution functions are Gaussian, and that the spectral intensity measured with the IP is of the form $S(\omega) = K/\omega[1+(\omega\tau_0)^2]$, where the relaxation time $\tau_0$ was related to the dimensionless constants of the Vinen theory. The form of $S(\omega)$ obtained with the SP was less certain due to noise inherent in the resistive film transducers. More recently, they have studied the fluctuations with two more probes. A digital, data acquisition and processing system was used to compute the autocorrelation and spectral intensity functions directly from time domain data.

**5895 Dependence of helium film thickness on temperature.** Horn, J.L.; Matheson, C.C. (East Anglia Univ. (UK). School of Mathematics and Physics). pp 384-387 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The experimental results reported indicate that more than one film thickness is possible at any temperature. Moreover, the observed variation of film thickness with temperature depends on the history of the film.

**5896 Helium film drainage.** Horn, J.L.; Matheson, C.C. (East Anglia Univ. (UK). School of Mathematics and Physics). pp 388-391 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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In a previous paper a preliminary note was presented on some observed differences between the helium film formed by superflow onto an initially bare surface above a bath of liquid helium II and the film left behind after bulk liquid helium II had drained away from the surface. Further, more detailed experimental observations of the same phenomenon are reported.

**5897 Ultrasonic attenuation in the vicinity of the lambda-point of helium.** Ikushima, A.; Tozaki, K. (Tokyo Univ. (Japan). Inst. for Solid State Physics). pp 231-233 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The purpose of the present work is, by measuring the attenuation at frequencies ranging between 3.17MHz and 1GHz, to know how to explain the different behaviours between low and high frequency results.

**5898 Thermodynamic properties of $^3$He-$^4$He mixtures very close to the superfluid transition temperature.** Kakizaki, A.; Satoh, T. (Tohoku Univ., Sendai (Japan). Dept. of Physics). pp 317-320 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Measurements were made on specific heats, and molar volumes in the neighbourhood of T/sub lambda/ under the saturated vapour pressure. The pressure dependence of Tsub(lambda), [(dT/dP)/sub lambda/], and the temperature of the minimum molar volume, T/sub M/, were also measured. Samples were pure $^4$He and $^3$He—$^4$He mixtures with $^3$He concentration x=3.85, 10.0 and 15.0%.

**5899 Superfluid fraction in $^4$He in a confined geometry near T/sub lambda/.** Kaplan, J.M.; Guernsey, R.W. Jr. (Columbia Univ., New York (USA). Columbia Radiation Lab.). pp 199-202 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

An apparatus capable of high precision mechanical measurements on both bulk and restricted geometry helium samples has been constructed. The primary goal is to measure the velocity difference between the normal fluid and superfluid for low-lying quantized circulation states in an annular container. Preliminary results are encouraging: it has been demonstrated that the equipment has sufficient sensitivity to resolve single quantized states. However, a spurious signal is presently masking the desired effect. Work on this experiment is proceeding.

**5900 Light scattering from interacting roton pairs in superfluid $^4$He.** Kobe, D.H.; Latham, W.P. Jr. (North Texas State Univ., Denton (USA)). pp 169-172 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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During the past few years, experiments have been performed in which laser light has been scattered from superfluid $^4$He. In addition to the Brillouin scattering due to phonons, Raman scattering due to roton pairs with essentially equal and opposite momentum has also been observed. The model does not, however, take into account the intrinsic width of the bound roton pair due to decay into two phonons, which has been observed in recent high resolution experiments. The continuum states above the threshold for the production of two free rotons is also not included, although they are responsible for the higher intensity of the peak in the observed cross section on the high energy side.

This theory has now been extended to take these effects into account.

**5901 Magnetic field dependence of the $^3$He melting curve and of the superfluid B transition.** Kummer, R.B.; Mueller, R.M.; Adams, E.D.; Kirk, W.P.; Greenberg, A.S.; Lee, D.M. (Florida Univ., Gainesville (USA). Dept. of Physics and Astronomy). pp 509-512 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Measurements are reported of the melting pressure for several fields up to B=1.2 T for temperatures as low as 1 mK where ordering in the solid occurs. In the course of the work, observations of the transitions into the A and B superfluid phases of liquid $^3$He were made. The B transition was followed to fields as high as 0.45 T, which is higher than in other reported work.

**5902 Some properties of superfluid $^3$He in the paramagnon model.** Kuroda, Y.; Nagi, A.D.S. (Waterloo Univ., Ontario (Canada). Dept. of Physics). pp 53-56 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The nuclear spin susceptibility and the superfluid mass density of superfluid $^3$He is calculated by using the paramagnon model. The results are compared with experiments.

**5903 Anisotropy and sound propagation in superfluid $^3$He.** Lawson, D.T.; Bozler, H.M.; Lee, D.M. (Cornell Univ., Ithaca, N.Y. (USA). Lab. of Atomic and Solid State Physics). pp 92-95 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Measurements of the attenuation and velocity of 20 MHz compressional waves have demonstrated that an applied magnetic field produces distinctive ordering in superfluid $^3$He-A. All of the authors' results to date seem consistent with (1) the alignment of the $^3$He-A energy gap axis perpendicular to an applied magnetic field, (2) the primary dependence of anisotropic effects on the angle between the sound propagation direction and this gap axis, and (3) the formation of 'textures', of various distributions of the gap axis within the plane perpendicular to the applied field, each time the A phase is formed.

**5904 Hydrodynamic model for superfluid helium with vortices.** Lhuillier, D.; Francois, M. (Paris-6 Univ., 75 (France)). pp 177-180 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Although their existence is experimentally well verified, the so-called mutual friction force F/sub sn/ and superfluid friction force F/sub s/ cannot emerge from the Landau irrotational model of superfluidity. Up to now these forces have merely been added to the Landau equations but this is untenable since, as a consequence, one destroys the irrotationality condition with which the equations have expressly been built. It is shown that these friction forces appear in a natural way in a model where superfluid helium with vortices is compared to a fluid with a conserved intrinsic momentum.

**5905 Measurement of the thermal diffusion ratio in $^3$He/$^4$He mixtures near the lambda-point.** Lucas, P.; Penman, D.; Tyler, A. (Manchester Univ. (UK)). pp 329-332 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Experiments are reported which support the expectation that k/sub T/, the thermal diffusion ratio, is of order $10^{-3}$ as for classical liquids well above T/sub lambda/, but rises to the 'superfluid' value as T is reduced below T/sub lambda/ in a $^3$He/$^4$He mixture, when the mass flux of the $^3$He component transported by diffusion is zero.

**5906 Behavior of millipore Rayleigh disk in rotating liquid helium II.** Lynch, R.F.; Pellam, J.R. (California Univ., Irvine (USA). Dept. of Physics). pp 203-206 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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In an effort to separate the contributions of the superfluid and normal fluid components the authors have been investigating the behavior of millipore disks in the same configuration described previously. The plots of observed angular deflection versus temperature show a most surprising result. The millipore disk deflections show an essential asymmetry in that the disk turns either crosswise or parallel to the flow direction depending upon the sense of rotation.

**5907 Nonlinear spin waves in the superfluid $^3$He-B.** Maki, K. (University of Southern California, Los Angeles (USA). Dept. of Physics). pp 37-40 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The nonlinear spin waves in the wall fixed configuration of the B phase are considered. The situation in which the liquid $^3$He is found between two parallel plates perpendicular to the Y axis is considered. Furthermore, a small inhomogeneous magnetic field H(z) is applied along the z axis. The spatio-temporal behaviour of the magnetization after the inhomogeneous field is suddenly turned off at t=0 is studied.

**5908 Magnetic Kapitza conductance at the interface between superfluid phases of liquid $He^3$ and CMN.** Maki, K. (University of Southern California, Los Angeles (USA). Dept. of Physics); Mills, D.L. (California Univ., Irvine (USA). Dept. of Physics); Beal-Monod, M.T. (Paris-11 Univ., 91 - Orsay (France). Lab. de Physique des Solides). pp 73-75 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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A preliminary calculation is presented of what is expected for the rate at which spin-spin interactions produce energy transfer (Kapitza conductance R/sub K/$^{-1}$) across an interface between an array of paramagnetic local moments, of the type encountered in CMN, and the degenerate Fermi gas of liquid $He^3$ in its superfluid phases A and B. It is found that, for decreasing temperature, while the Kapitza conductance R/sub K/$^{-1}$ increases in the normal phase of $He^3$, it then decreases once one reaches the A phase transition and decreases even more in the B phase, so that one would expect very tiny heat transfer near 0K, which sounds reasonable physically. The only experiment so far agrees with this conjecture for the A phase, but goes in the opposite direction from prediction in the B phase.

**5909 Large quantum number vortex and equilibrium surface profiles of rotating liquid helium II.** Marston, P.L. (Stanford Univ., Calif. (USA). Dept. of Physics). pp 268-271 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A new method of measuring the detailed surface contour of rotating He II at low rotation rates is Fizeau optical interferometry. This is perhaps the first use of interferometry to measure the profile of any rotating fluid. Surface deformations like those predicted for a multiply quantized superfluid vortex were observed for the first time. This provides additional evidence that superfluid flow contributes to the Bernoulli pressure at the free surface, a topic of recent discussion.

**5910 Liquid $^3$He viscosity: pressure dependence, 0.4 to 1K.** McCoy, R.J.; Steinback, M.; Lyden, J.K.; Guernsey, R.W. Jr. (Columbia Univ., New York (USA). Columbia Radiation Lab.). pp 8-083 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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An apparatus has been built to measure the $^3$He superfluid density and viscosity as a function of temperature and pressure. Viscosity measurements for T from 0.4 to 1.0K and pressure from 1 to 28 bar are reported.

**5911 Second sound in colour. Some Schlieren observations of resonances in helium II.** Mota, A.C.; Olsen, J.L.; Sorbello, R.S. (Eidgenoessische Technische Hochschule, Zurich (Switzerland). Lab. fuer Festkoerperphysik). pp 238-240 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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It has been shown elsewhere that standing waves of second sound in helium II cause deformations of the free surface that can be observed by a Schlieren method. The present work is devoted

to a detailed study of the surface patterns, and the use of colour facilitates the interpretation of the pictures seen.

**5912 Melting line of $^4$He near the upper lambda transition.** Mueller, K.H.; Pobell, F. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany). Inst. fuer Festkoerperforschung). pp 195-198 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The pressure P/sub m/ and temperature T/sub m/ of $^4$He have been measured along the melting line in the immediate vicinity of the upper lambda-point T/sub m, lambda/. This work was motivated by the uncertainty about the detailed behavior of the slope (dP/dT)/sub m/ of the melting line very close to T/sub m, lambda/ raised by Kierstead's earlier results.

**5913 Resonance states of rotons in superfluid $^4$He.** Nishiyama, T.; Watanabe, Y. (Osaka Univ., Toyonaka (Japan). Dept. of Physics). pp 157-160 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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On the basis of the collective description for rotons in superfluid $^4$He the resonance state of two rotons with opposite momenta is obtained by introducing an attractive interaction between rotons and rotons transmitted by phonons. Furthermore, the nature of the non-phonon peaks and the other kinds of resonance states are discussed by calculating the dynamical structure factor $S(Q,\omega)$ for wave numbers between $2A^{-1}$ and $3.6A^{-1}$.

**5914 Effective interaction in $^3$He by Pandharipande's method.** Niskanen, J.A.; Green, A.M.; Vuorio, M. (Helsinki Univ. (Finland). Research Inst. for Theoretical Physics). pp 61-64 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The superfluid transition of $^3$He was originally thought to take place into a relative d-wave paired state, but experiments showed that either p-waves or f-waves are more likely. To elucidate this problem the question of the effective interaction as a function of L, the relative angular momentum, is reconsidered. The method used for the calculation is Pandharipande's variational approach. The results are very similar to those given by the Brueckner method, and therefore the p-wave versus f-wave controversy still exists.

**5915 Pulsed NMR frequency shifts in $^3$HeB.** Osheroff, D.D. (Bell Telephone Labs., Inc., Murray Hill, N.J. (USA)); Corruccini, L.R. (California Univ., Davis (USA). Dept. of Physics). pp 100-103 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The authors recently reported observations of the precession of the nuclear magnetic moment, M, in superfluid $^3$He using pulsed nuclear magnetic resonance (NMR) techniques. A detailed study has now been made of the precession of M in $^3$HeB at melting pressures following a known tipping pulse utilizing the apparatus and procedures described previously, in light of the new theoretical work. The results can be described as follows: (I) For PHI<approximately95° the magnetic moment precesses about $H_0$ at precisely $\gamma H_0$, and the free induction signal decays away in a time comparable to the equivalent time observed in the Fermi liquid (approximately 35 ms). The magnitude of this signal is proportional to sin PHI as expected. (II) For 95°<approximately PHI <approximately 104° the magnetic moment continues to precess at nearly $\gamma H_0$, but the free induction signal decays away more rapidly than it does for PHI<approximately95° particularly near 104°. As PHI increases toward 104° irregular modulations in the envelope of the free precession signal develop which damp out within a few milliseconds following the tipping pulse.

**5916 Experimental study of the ion-vortex interaction.** Ostermeier, R.M.; Glaberson, W.I. (Rutgers--the State Univ., New Brunswick, N.J. (USA). Dept. of Physics). pp 252-255 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Because of their microscopic size, ions provide a unique means of probing the structure of vortices in He II. In this paper measurements are reported of the cross section for the capture of ions by vortex lines and the escape rate of ions from vortex lines in pure $He^4$ and $He^3$—$He^4$ solutions.

**5917 Thermal diffusion in tricritical $^3$He—$^4$He mixtures.** Papoular, M. (Centre National de la Recherche Scientifique, 38 - Grenoble (France). Centre de Recherches sur les Tres Basses Temperatures). pp 333-336 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The structure of the slow osmotic mode is discussed in the tricritical region in terms of a divergent thermal diffusion ratio. It is shown that recent quasi-elastic light scattering results in the superfluid are consistent with a symmetric scaling: k/sub T/ approximately = epsilon$^{-1}$, for T ><T/sub t/.

**5918 Collective modes in superfluid $^3$He.** Patton, B.R. (Massachusetts Inst. of Tech., Cambridge (USA)). pp 17-20 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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A set of equations which describe the collective modes of an anisotropic superfluid in the collisionless limit is derived. In the absence of the spin-orbit interaction, in general modes describing the separate oscillation of the spin and orbit degrees of freedom are obtained. In the axial or ABM state both the spin modes derived by Combescot and others, as well as a new set of orbit modes which result from the rotational degeneracy of the anisotropic pair wave function are obtained.

**5919 Superfluid film in non-superfluid mixtures of $^4$He in $^3$He.** Peshkov, V.P. (AN SSSR, Moscow. Inst. Fizicheskikh Problem). pp 356-359 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Already in the very first experiments on phase separation, which takes place in the liquid mixtures of $^3$He and $^4$He, a phenomenon was observed indicating superfluid motion through the upper, $^3$He-rich, phase of liquid. However, later experiments, like the propagation of sound and others, showed that the $^3$He-rich phase of the liquid mixture is a non-superfluid phase. The experiments discussed below explain this conflict and show that all along the surface of a solid body inside the upper $^3$He-rich phase a superfluid film is formed originating from the lower $^4$He-rich phase.

**5920 Low temperature viscosity and thermal conductivity of superfluid $^3$He.** Pethick, C.J.; Bhattacharyya, P. (Illinois Univ., Urbana (USA). Dept. of Physics); Smith, H. (Copenhagen Univ. (Denmark). H.C. Oersted Inst.). pp 5-8 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The viscosity and thermal conductivity of the Balian-Werthamer state have recently been calculated by the present authors in the limit of low temperatures, where k/sub b/T<<$\Delta$, the (isotropic) energy gap. Quantitative estimates for liquid $^3$He have been made using an effective interaction between quasiparticles in the superfluid obtained by performing a Bogoliubov transformation on the normal state effective interaction. The viscosity at zero temperature is estimated to be about one quarter of the normal state viscosity at the transition temperature. The thermal conductivity kappa/sub D/ is obtained in a similar way from a Boltzmann equation involving the same relaxation time. It is independent of $\Delta$ and nearly equal to the Fermi liquid heat conductivity at that temperature.

**5921 Thickness of an accelerating superfluid film.** Petrac, D.; Wang, T.G. (California Inst. of Tech., Pasadena (USA)). pp 392-395 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Bernoulli thinning without vapor exchange was examined. The conclusions from this experiment are: (1) Acceleration has a significant effect on the thickness of a moving superfluid film. (2) No thickness change between static and steady-flow film was observed. (3) If the observed acceleration phenomenon is the cause of the discrepancy between oscillating and steady-flow experiments in determining the Bernoulli term, then either the Bernoulli term does not apply in HeII films, or there are severe inadequacies in the two fluid hydrodynamics equations for HeII films, or there are specific unknown conditions of the particular experiments (like departures from isothermal and isobaric conditions) for which the Kontorovich equation does or does not apply.

**5922 Size effect and the effect of a magnetic field on the phase diagram of superfluid $^3$He.** Privorotskii, I.A. (Technion-Israel Inst. of Tech., Haifa. Dept. of Physics). pp 65-68 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The size effect produced by the surface tension on the A-B coexistence curve in the vicinity of the polycritical point is considered. An analogous effect can be calculated also for a massive sample in a weak magnetic field H. It confirms that the change of free energy in a magnetic field can be considered as a small perturbation, and the susceptibilities do not depend on H.

**5923 Surface tension and boundary conditions for superfluid Fermi-liquid.** Privorotskii, I.A. (Technion-Israel Inst. of Tech., Haifa. Dept. of Physics). pp 69-72 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The surface tension and boundary conditions for the superfluid Fermi liquid are obtained from the Ginzburg Landau equations. Boundary conditions can be obtained from the requirement that the surface part of the variation of the total free energy must be equal to zero.

**5924 Sound propagation in the B phase of superfluid $^3$He.** Roach, P.R.; Abraham, B.M.; Roach, P.D. (Argonne National Lab., Ill. (USA)); Ketterson, J.B. (Northwestern Univ., Evanston, Ill. (USA)). pp 88-91 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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The authors have recently measured the velocity and attenuation of 20 MHz sound in the B phase of $^3$He at a pressure of 21.00 bar. The low temperatures were achieved by demagnetizing cerium magnesium nitrate contained in the epoxy sound cell; this cell could be coupled to the dilution refrigerator by a mechanical heat switch. The results strongly suggest that there is a very good agreement between theory and experiment as to the position of both peaks in the attenuation data but that considerably more life time broadening is being observed than has been incorporated in the theory.

**5925 Thermodynamic phenomena on vortex lines in superfluid helium.** Shikin, V.B. (AN SSSR, Chernogolovka. Inst. Fiziki Tverdogo Tela). pp 184-186 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

It is well known that the existence of surface thermal and impurity excitations in liquid helium cause an experimentally observed temperature dependence of the surface tension and other thermodynamic effects. It can be expected that absorption of thermal excitations on vortex lines will be accompanied by similar phenomena. So far this problem, however, has not been discussed, since the real observations of thermodynamic effects were not available. The present note proves that such effects do exist.

**5926 Ion mobility in superfluid $^3$He.** Soda, T. (Tokyo Univ. of Education (Japan). Dept. of Physics). pp 13-16 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

An expression is derived for the ion mobility in superfluid $^3$He by considering a slowly moving charged impurity under an electric field E. The method used by Baym et al. for the Bose superfluid is extended to the Fermi anisotropic superfluid.

**5927 Mutual friction force between the normal fluid and vortices in rotating superfluid helium.** Sonin, E.B. (AN SSSR, Leningrad. Fiziko-Tekhnicheskij Inst.). pp 181-183 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In order to derive the expression for the force on the vortex it is necessary to calculate the momentum flux tensor at distances from the vortex that are less than the mean free path of quasiparticles and more than the distances contributing to the scattering. The momentum flux tensor determines the total flow of the momentum through the cylinder surrounding the vortex. In the quasiclassical study of roton scattering the expression connecting the momentum flux tensor and the distribution function of rotons which is found by solving the classical equations of motion along the roton trajectories can be used. In the phonon case the derivation of the friction force equation is based on the hydrodynamical approach developed by Pitaevskii.

**5928 NMR properties of $^3$He-A contained in a flat slab.** Takagi, S. (Sussex Univ., Brighton (UK). School of Mathematical and Physical Sciences). pp 49-52 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The anomalous NMR properties of the A phase of liquid $^3$He contained in a flat slab of thickness D much larger than the coherence length and much smaller than a characteristic thickness D/sub c/ with a static magnetic field H applied perpendicular to the slab are discussed.

**5929 Self-consistent calculation of the longitudinal NMR for the BW state of superfluid $^3$He.** Tewordt, L.; Fay, D.; Doerre, P.; Einzel, D. (Hamburg Univ. (F.R. Germany)). pp 41-44 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Some of the results of a quasi-exact calculation for the Balian—Werthamer (BW) state are reported. Although the assumption of the collisionless regime does not meet the actual situation near T/sub c/, it seems nevertheless important to have the results of a rigorous RPA-type calculation for comparison with other work.

**5930 Nature of He II thermal counterflow at large heat currents.** Tough, J.T.; Ladner, D.R.; Childers, R.K. (Ohio State Univ., Columbus (USA). Dept. of Physics). pp 223-226 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The authors have previously emphasized that there are two heat II currents in He II thermal counterflow. In recent temperature and pressure gradient data the heat currents noted divide the flow into three regimes. It is possible that the third regime ($Q>Q_s$) exhibits some modified form of mutual friction but would seem more likely to suppose that in this third regime effects due to a non-Poiseulle flow of the normal fluid are observed. In this paper two further measurements are presented at high heat currents which suggest the third flow regime is associated with a modified flow of the normal fluid.

**5931 Pressure and temperature gradients in He II counterflow.** Tough, J.T.; Childers, R.K. (Ohio State Univ., Columbus (USA). Dept. of Physics). pp 227-230 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Investigations of He II counterflow have been extended to include the simultaneous determination of the temperature and pressure gradients accompanying the flow. Previous measurements of the pressure gradient neither agree nor suggest the role of mutual friction. The present results confirm the speculation of Vinen that the mass of quantized vortex lines responsible for the mutual friction force is also the source of an eddy viscosity of the turbulent superfluid.

**5932 Spontaneous acceleration of freely rotating helium II and similar phenomena in pulsars.** Tsakadze, J.S.; Tsakadze, S.J. (AN Gruzinskoj SSR, Tbilisi. Inst. Fiziki). pp 283-286 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In 1969 Packard and Sanders found that the number of vortices in the accelerated or moderated rotating He II changes in jumps. Hence, the change of He II rotation regime is accompanied by specific relaxation processes characteristic for the superfluid, connected with the formation of the long-lived metastable states. In 1972 Packard assumed that the jumping disappearance of vortex groups in the moderately rotating pulsar might be a cause of their acceleration. Actually, if the vortices, like those in He II, are disappearing by groups in the moderately rotating superfluid neutron liquid their moment will be transferred to the solid shell of the pulsar and it will accelerate. If one compares the evaluations of the change in the number of vortices in the experiment of Packard and Sanders and in pulsars they turn out to be quite different.

**5933 Experimental study of persistent filmflow in He II.** Verbeek, H.J.; van Spronsen, E.; van Beelen, H.; de Bruyn Ouboter, R.; Taconis, K.W. (Rijksuniversiteit Leiden (Netherlands). Kamerlingh Onnes Lab.). pp 411-414 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Three different methods involving rotation or acceleration were used to create persistent film flow. In all these methods the film covers the inside wall of a long glass capillary (between 123 m and 200 m), wound into a spiral with radius R. The film is in contact with bulk helium in the closed ends of the capillary, serving as vertical standpipes. The film behaviour is studied by monitoring the liquid levels in the standpipes.

**5934 Light scattering from liquid helium close to the lambda-line.** Vinen, W.F.; Palin, C.J.; Lumley, J.M.; Hurd, D.L. (Birmingham Univ. (UK). Dept. of Physics); Vaughan, J.M. (Royal Radar Establishment, Malvern (UK)). pp 191-194 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

New measurements on the spectrum of light scattered by liquid helium close to the lambda line are presented. The observations relate particularly to lineshapes and linewidths associated with entropy fluctuations in the hydrodynamic regions both below and above the lambda-point, and to the way in which the spectra in these two regions merge in the critical region very close to the transition.

**5935 Onset diagram of superfluid helium film.** Wang, T.G. (California Inst. of Tech., Pasadena (USA)). pp 399-402 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Onset phenomena associated with unsaturated liquid He II film have recently stimulated great interest in the scientific community. Some novel observations of onset phenomena obtained by measuring the rotational decay time constant $\alpha$ of a rotating sphere coated with superfluid film are reported. The rotating sphere was an ultrapure, superconducting, niobium ball of 1-in diameter and 5-$\mu$in. sphericity.

**5936 2-D excitations in very thin helium films.** Washburn, T.E.; Rutledge, J.E.; Mochel, J.M. (Illinois Univ., Urbana (USA). Dept. of Physics). pp 372-375 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Using a resonance technique third sound velocity has been measured to better than one part in $10^4$ down to 0.1 K in superfluid films of $^4$He on an argon substrate. The model used to explain the results is a two dimensional gas of phonon-like and roton-like thermal excitations.

**5937 Production and measurement of vortex rings in superfluid helium.** Waters, C.A.; Fairbank, W.M. (Stanford Univ., Calif. (USA). Dept. of Physics). pp 272-274 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

An experiment is in progress to measure the properties of the vorticity produced when superfluid helium flows through a circular orifice at a rate in excess of the critical velocity. In the Feynman theory of Helium II the energy dissipated in such flow is believed to produce quantized vortex rings of a size approximately that of the orifice. This experiment differs from most other vortex ring experiments in that the ion-trapping property of vortices is not used for either production or detection of rings. Instead mechanical methods are used to produce the ring and measure its dynamic properties.

**5938 Trapped ion lifetimes in $^3$He—$^4$He superfluid mixtures.** Williams, G.A.; Packard, R.E. (California Univ., Berkeley (USA). Dept. of Physics). pp 360-363 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Several researchers have suggested that in $^3$He—$^4$He mixtures the $^3$He atoms may condense on the vortex core or on the surface at the electron bubble. A sensitive test of these predictions can be made by measuring the trapped lifetime in $^3$He—$^4$He mixtures. A large number of such measurements have been performed over the temperature range 0.1K—1.3K in mixtures with $^3$He concentrations in the range .01%—4.8%.

**5939 Theory of ultrasound propagation in superfluid $^3$He: collision effects.** Woelfle, P. (Max-Planck-Institut fuer Physik und Astrophysik, Muenchen (F.R. Germany)). pp 25-28 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In previous theories of ultrasound propagation in superfluid $^3$He, the effects of quasiparticle collisions were neglected. In this work these effects are included by adding a collision integral to the transport equation in the kinetic equation formalism, thus allowing for collision damping of the collective modes.

## OTHER QUANTUM FLUIDS

*REFER ALSO TO CITATION(S) 5454, 5866*

**5940** (BNL—21404) **Neutron scattering from quantum liquids.** Cowley, R.A. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 19p. (CONF-760601—10). Dep. NTIS $3.50.

From Conference on neutron scattering; Gatlinburg, Tennessee, United States of America (USA) (6 Jun 1976).

Recent neutron scattering measurements on the quantum liquids $^4$He and $^3$He are described. In the Bose superfluid there is a well-defined excitation for wave vectors less than 3.6 $A^{-1}$. In the Fermi liquid measurements are much more difficult because of the large absorption cross section, but measurements at the Institute Laue—Langevin have shown that there are no well-defined excitations at 0.63 K for wave vectors between 1.0 and 2.6 $A^{-1}$. The difference between these results is due to the existence of particle—hole excitations in the Fermi liquid into which collective excitations can decay. Because of the simplicity of the excitations in $^4$He, it has become a testing ground for the effects of the interactions between the excitations. Measurements are described which show that while roton—roton interactions are attractive at small wave vectors, they are repulsive at larger wave vectors. The scattering at large momentum transfer in $^4$He has been measured, but its interpretation is still open to question.

**5941 Liquid solid surface tension in $^4$He.** Angeletti, F.; Goodstein, D.; Savoia, A.; Scaramuzzi, F. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratori Nazionali di Frascati). pp 301-304 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

According to a widely accepted model due to Atkins, the positive ion in liquid helium is actually a sphere of solid helium frozen by electrostrictive pressure owing to the positive charge in its center. In this view, the size of the sphere would grow without limit as the pressure applied to the liquid, P, is increased toward the bulk melting pressure P/sub m/, were it not for the effect of the liquid-solid surface tension, sigma/sub ls/. Far from the melting curve, the surface tension is not a significant factor, but close to melting the size of the ion complex is governed by it. Use has been made of this effect to measure sigma/sub ls/. Internal analysis of the data indicates that they are consistent with the Atkins model, but sigma/sub ls/ is found to have a temperature dependence that would be difficult to understand if it were taken to be equal to the surface tension of bulk $^4$He.

**5942 Quantum-hydrodynamics of a many-boson system.** Biswas, A.C. (Tata Inst. of Fundamental Research, Bombay (India)). pp 173-176 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Using the formalism of action-angle variables developed by the author, the complete set of Quantum Hydrodynamic equations for a many-boson system have been derived. These equations reduce to the Landau-Khalatnikov two-fluid Hydrodynamic equations in the long-range limit.

**5943 Relaxation effects and slip at an oscillating solid surface in helium-3.** Bolton, J.P.R. (Lancaster Univ. (UK)). pp 115-118 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The paper introduces a model which gives an intuitive understanding of the relaxation effects accompanying the transmission of transverse waves in the Fermi liquid phase of $He^3$, and applies it to an investigation of the reduction, due to slip, in the efficiency of excitation of these waves at a solid surface. The calculation is complete only at frequencies low enough for any possible Kapitza enhancement to be neglected.

**5944 Roton emission by negative ions travelling faster than the Landau critical velocity.** Bowley, R.M.; Sheard, F.W. (Nottingham Univ. (UK)). pp 165-168 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Recent experiments by Phillips and McClintock have shown that it is possible for negative ions in liquid helium, under pressure greater than 15 bar, to travel substantially faster than the Landau critical velocity, v/sub L/. In retrospect the earlier work of Rayfield and of Zoll and Schwarz is consistent with this observation. However it is now clear that the dependence of the average velocity v(ave) on the electric field E disagrees with the formula predicted by Takken.

**5945 Liquefaction peak of 2nd layer $^4$He films on graphite.** Bretz, M.; Polanco, S.E. (Michigan Univ., Ann Arbor (USA). Dept. of Physics). pp 451-454 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

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Preliminary results of an extended specific heat investigation of 2nd layer $^4$He films are presented. A grafoil cell was used, placed in a $^3$He cryostat capable of reaching 0.3K. The dependence of the specific heat on the areal density of the film is described.

**5946 Surface electron barriers for helium-3 and helium-4: experimental study of density dependence.** Broomall, J.R.; Onn, D.G. (Delaware Univ., Newark (USA). Dept. of Physics). pp 439-442 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In order to avoid the pressure limitations inherent in studying electrons at a liquid-vapor interface, hot electrons were injected directly into the helium fluid from the gold surface of a cold cathode (Al-oxide-Au) thin-film emitter. This device provides electrons of known energy distribution averaging about 1 eV. The electron emitters are mounted in a stainless steel pressure cell, capable of exceeding 100 atmospheres. A temperature range of 1.3°K to room temperature then provides a wide range of helium densities in all phases. The injected current is collected at a gold-plated anode and measured as a function of atomic density of the helium sample and applied electric field strength E up to 60,000V/cm.

**5947 Attenuation of first sound in $^3$He—$^4$He mixtures near T/sub lambda/.** Buchal, C.; Pobell, F. (Kernforschungsanlage Juelich G.m.b.H. (F.R. Germany). Inst. fuer Festkoerperforschung). pp 337-340 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Dispersion and attenuation of first sound have been measured in $^3$He-$^4$He mixtures at frequencies 2 kHz < = omega/2$\pi$ < = 600 kHz, and in the temperature range 1$\mu$K < = absolute value of [T-T/sub lambda/] < = 10 mK. The investigated mixtures had molar $^3$He concentrations X = 0, 7.0, 19.4, 37.7, and 51.7%, respectively. Sound resonances were generated simultaneously at two frequencies in two copper resonators inside a copper chamber. In this communication the discussion is restricted to the attenuation measured at 600 kHz. The attenuation $\alpha$ is asymmetric about T/sub lambda/ with a peak in the superfluid phase. The shape of $\alpha$ in the mixtures is qualitatively similar to the shape of $\alpha$ in $^4$He, but its amplitude decreases strongly with $^3$He concentration, and at the same time the maximum of $\alpha$ moves away from T/sub lambda/.

**5948 Evaporation spectrum of $^4$He.** Caroli, C.; Roulet, B.; Saint-James, D. (Ecole Normale Superieure, 75 - Paris (France). Groupe de Physique des Solides). pp 147-149 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Existing theories of $^4$He evaporation into vacuum (or vapour) predict that one should observe, in the single-particle emission spectrum, an enhancement at the energy corresponding to excitations in the fluid near the roton minimum. The tunnelling theory of Caroli et al., which is exact in its 'continuous' formulation, has shown that, for a metal, the kinetic theory is exact. The authors have, therefore, tried to use it for $^4$He, in order to determine whether some kind of kinetic model could be used. In $^4$He, however, the situation is somewhat more involved since, above the roton minimum, there are three different excitations corresponding to a given energy $\omega$. The extension is, nevertheless, straightforward if one assumes that the atomic density n(x) is a step function at the liquid-vacuum separation.

**5949 Effects of surface normal motion for helium films.** Cole, M.W. (Pennsylvania State Univ., University Park (USA). Dept. of Physics); Bretz, M.; Sander, L.M. (Michigan Univ., Ann Arbor (USA). Dept. of Physics). pp 419-422 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The study of helium films has been motivated in part by the hope that the film's properties would be characteristic of two-dimensional (2D) matter. The effects of motion in the dimension normal to the surface are investigated. It is found that this motion can be neglected for the first layer, but that it has an important role for He atoms in the second layer. The conclusions agree qualitatively with experiment.

**5950 Improved Jastrow wavefunction for liquid helium four.** De Michelis, C.; Reatto, L. (Milan Univ. (Italy). Istituto di Fisica). pp 131-134 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The ground state properties of liquid $^4$He are rather successfully described by a Jastrow type wavefunction psi/sub J/($r_1$....r/sub N/)=exp[-1/2u(r/sub ih/)], with the McMillan s form u(r) (b/r)$^5$ or with the more complicated form which has been introduced by Kalos, Levesque and Verlet and which is called u/sub KLV/(r). These u functions are decreasing functions of r and this implies that psi/sub J/ does not properly describe a self binding state. The authors have already reported that u functions exist which contain attractive correlations strong enough that psi/sub J/ describes a self binding state and at the same time the expectation value E/sub J/=<psi/sub J/Hpsi/sub J/> for the ground state energy is as low as in the previous calculations, and they now report on subsequent calculations which confirm the previous conclusions also when the repulsive part of u(r) is u/sub KLV/(r).

**5951 Structure of T=0 liquid $^4$He near model solid substrates.** Ebner, C.; Saam, W. (Ohio State Univ., Columbus (USA). Dept. of Physics). pp 447-450 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Applications are reported of a recently developed density-functional (DF) theory of T=0 liquid $^4$He to the problem of determining the detailed structure of this liquid near a planar solid substrate which exerts an attractive force on the $^4$He atoms. First, for a substrate modeled on solid $^4$He, will the theoretical results indicate incipient solid $^4$He monolayer formation at the liquid-substrate interface when the liquid density far from the interface is equal to the experimentally observed liquid solidification density. Second, for liquid pressure P=0, can definite statements be made about substrate potential strengths required to produce a solid layer of $He^4$ next to the substrate.

**5952 Theoretical argument against the existence of a Bose Einstein Condensate in interacting boson systems.** Evans, W.A.B. (Kent Univ., Canterbury (UK)). pp 127-130 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Recent inelastic neutron scattering measurements at high momentum transfers in superfluid $^4$He were initially proposed to directly measure any Bose Einstein Condensation (BEC) that may be there, but subsequent careful analysis of the 1.2°K data of Mook, Scherm and Wilkinson by Jackson has shown the results to be consistent with the complete absence of a BEC. The aim of this paper is to lend theoretical support for the non-existence of a BEC in all interacting boson systems with a grand-canonical Hamiltonian.

**5953 Quartz crystal as a probe of chemical potential for the helium film.** Forder, P.W.; Halse, M.R.; Brown, J.B. (Kent Univ., Canterbury (UK)). pp 396-398 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Measurements of the thickness of a saturated helium film obtained with a quartz microbalance have been extended using AC-cut crystals operated at frequencies of 3MHz and 10MHz. Further experiments have shown that the smooth variation of crystal frequency with film thickness has superimposed on it a small variation which is periodic in the height of the crystal above the bath.

**5954 Measurement of viscosity of $^4$He above 4.2K by a vibrating wire viscometer.** Goodwin, J.M. (Kyoto Univ. (Japan). Dept. of Physics). pp 297-300 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Measurements of the viscosity of $^4$He have been made using a vibrating wire viscometer near the gas-liquid critical point and along the saturated vapor pressure curve from 4.2 K up to the critical point. The density and viscosity are both determined from the damping and the shift in the period of oscillation of the wire.

**5955 Spectroscopy of electrons in surface states outside liquid helium.** Grimes, C.C.; Brown, T.R.; Burns, M.L.; Zipfel, C.L. (Bell Labs., Murray Hill, N.J. (USA)). pp 443-446 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Electrons can be bound 100 A above a free surface of liquid helium in the potential well formed by the sum of the long-range attractive image potential and the short-range electron-atom repulsive potential. Spectroscopic studies of electronic transitions between bound states are conveniently performed at fixed frequency by utilizing Stark-effect tuning of the splittings.

**5956 Theory of dilute mixtures of $^3$He in liquid $^4$He.** Ichimura, H.; Shimojima, K. (Tokyo Inst. of Tech. (Japan). Dept. of Physics). pp 309-312 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In recent years remarkable progress has been achieved concerning the theory of dilute mixtures of $^3$He in liquid $^4$He. However, the simple microscopic theory based essentially on a hard-sphere model can still claim its existence. The results of calculations which have been done as an application of a general theory of quantum mixtures in which both the statistical and the dynamical quantum effects play important roles are presented.

**5957 Pressure dependence of thermal conductivity of liquid $He^3$ at very low temperatures.** Kodama, T.; Morii, Y.; Fujii, Y.; Kubota, M.; Shigi, T. (Osaka City Univ. (Japan). Faculty of Science). pp 84-87 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In the present work, the pressure dependence of thermal conductivity in the limit TyieldsO, and its finite-temperature corrections to the limiting low-temperature behaviour of a normal Fermi liquid were investigated. Experiments were made under the pressure of 1.30, 10.0, 20.0 and 27.0 kg/cm$^2$ and at temperatures from 300mK down to 20mK.

**5958 Dynamic structure factor for liquid $He^4$ and quantum lattice model.** Lee, M.H. (Georgia Univ., Athens (USA). Dept. of Physics). pp 150-153 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

It has been realized for some time now that the quantum lattice model (or the anisotropic Heisenberg antiferromagnetic model) is a useful model for studying the properties of quantum liquids especially near the lambda transition. The static critical values calculated from the quantum lattice model are in good agreement with the observed values. Furthermore, it was shown recently that there are collective modes in the quantum lattice model which are equivalent to the plasmons. Hence, it would seem to be interesting to study the dynamic structure factor for the quantum lattice model and to make a comparison with experiment. Work on the dynamic structure factor is reported here.

**5959 Tricritical slowing-down of superfluid dynamics in $^3$He-$^4$He mixtures.** Leiderer, P.; Nelson, D.R.; Watts, D.R.; Webb, W.W. (Cornell Univ., Ithaca, N.Y. (USA)). pp 321-324 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The first measurements of dynamical properties at a tricritical point are presented. Using light scattering it was found that at the tricritical point [T/sub t/, x/sub t/] of $^3$He-$^4$He mixtures concentration fluctuations in the superfluid phase slow down with a temperature dependence even more pronounced than at conventional critical points.

**5960 Theory of thermal properties of nearly ferromagnetic fermi systems, e.g. liquid $He^3$.** Mishra, S.G.; Ramakrishnan, T.V. (Indian Inst. of Tech., Kanpur. Dept. of Physics). pp 57-60 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A microscopic spin fluctuation theory is described for thermal properties, e.g. spin susceptibility chi and specific heat C/sub v/, of nearly ferromagnetic fermi systems. The leading term for (T/T/sub F//sup free/)=tau<<1, and the first corrections thereto are obtained. A calculation of chi(tau) (0<tau<0.2) is made for liquid $He^3$, the agreement with experiment being very good.

**5961 Bose-Einstein condensation in a two-dimensional system at constant pressure.** Pathria, R.K. (Waterloo Univ., Ontario (Canada). Dept. of Physics); Chaba, A.N. (Universidade Federal da Paraiba, Departamento de Fisica, Joao Pessoa, Paraiba, Brazil). pp 364-367 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

It is well known that an ideal Bose system of dimensionality lower than 3 does not undergo Bose—Einstein condensation at finite temperatures. Recently, Imry, Bergman and Gunther have pointed out that if the system is cooled at a constant pressure P instead, a phase transition accompanied by a macroscopic condensation of particles in the lowest single-particle state epsilon$_0$ does take place at a finite temperature T/sub c/(P). Such a transition would be of relevance to the problem of superfluidity in thin helium films and to the thermodynamic behaviour of helium submonolayers. The main results are reported of a rigorous, asymptotic analysis of this problem carried out by using techniques developed by Pathria and collaborators. While some of the results of Imry et al. (in particular, the macroscopic occupation of the single-particle state epsilon$_0$ at finite temperatures below T/sub c/) are qualitatively upheld, others are found to require serious modifications.

**5962 New approach to the theory of excitations in many boson systems.** Rama Rao, I. (Tata Inst. of Fundamental Research, Bombay (India)); Rajagopal, A.K. (Indian Inst. of Science, Bangalore. Centre for Theoretical Studies). pp 143-146 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A new approach to the theory of interactions among the excitations in a many boson assembly is developed. This fresh approach is motivated by the fact that the existing theories have varied mathematical troubles associated with them and the formalism reported here does not share these. More significantly this enables the deeper underlying reason for the equivalence of the various existing theories to be found.

**5963 Evidence of the boundary interaction between electron spin and liquid $^3$He spin.** Saito, S. (Tohoku Univ., Sendai (Japan). Research Inst. for Iron, Steel and Other Metals). pp 119-122 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Several magnetic salts were chosen as electron spin systems interacting with the $^3$He nuclear spin, and $^3$He NMR and longitudinal relaxation time measurements were made by the cw method. The results found for Cu.T.A.S. (Copper tetrammine sulfate monohydrate, $Cu(NH_3)_4SO_4.H_2O$) as an electron spin system, are convincing that the electron spin plays an important role in the boundary interaction between $^3$He and magnetic materials.

**5964 Excitations in $^3$He—$^4$He mixtures.** Slinkman, J.; Ruvalds, J. (Virginia Univ., Charlottesville (USA). Dept. of Physics); Bagchi, A. (Maryland Univ., College Park (USA). Dept. of Physics); Rajagopal, A.K. (Indian Inst. of Science, Bangalore). pp 313-316 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The energy spectrum has been calculated for a system of Fermion impurities in a Boson field from a microscopic theory. To make a connection with $^3$He—$^4$He mixtures a pseudopotential is introduced which yields a good fit to the liquid structure factor, and the sensitivity of various features of the excitations to the model potential is determined.

**5965 Neutron inelastic scattering from liquid helium-three.** Stirling, W.G.; Scherm, R.; Volino, F. (Institut Max von Laue - Paul Langevin, 38 - Grenoble (France)); Cowley, R.A. (Edinburgh Univ. (UK)). pp 76-79 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In a previous publication measurements of neutron inelastic scattering by liquid $^3$He at 1.3K were presented. Further measurements, taken at the IN5 cold neutron time of flight spectrometer at the ILL, Grenoble, with much improved experimental conditions are reported. In particular, the sample temperature was lower (0.63 K) while considerable care was taken to separate the $^3$He scattering from the background. Despite the rapidly decreasing structure factor the measurements were extended to lower wavevectors in an attempt to observe a zero-sound mode.

**5966 Raman spectra of solid and liquid helium at large frequency shifts.** Surko, C.M.; Slusher, R.E. (Bell Labs., Murray Hill, N.J. (USA)). pp 487-490 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A study of the Raman spectrum of solid and liquid $^3$He and $^4$He at frequency shifts as large as 300 K is reported. The Raman spectrum expected from a process where an incident photon creates an energetic pair of nearly free helium atoms and a scattered photon is also calculated. The agreement of the model calculation with the experimental measurements indicates that this simple process dominates the spectra at frequency shifts larger than that necessary to create two phonons in the solids or two collective excitations in the liquids.

**5967 Minima in spin-lattice times in adsorbed helium.** Thompson, A.L.; Brewer, D.F.; Goto, Y. (Sussex Univ., Brighton (UK). School of Mathematical and Physical Sciences). pp 463-466 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Several measurements have been described of the spin-lattice ($T_1$) and spin-spin ($T_2$) relaxation times of $He^3$ films adsorbed on Vycor porous glass within the temperature range $0.3<T<1.5$K, at various coverages up to one monolayer. The aim of the present experiments was to explore these more fully over a more extensive range of frequency (0.59MHz to 2.06MHz) and temperature (0.3K to 4.2K). Minima were found in the spin-lattice recovery time as a function of temperature which are similar to those occuring in bulk solid.

**5968 Heat capacity study of second layer $^3$He films.** Van Sciver, S.W. (Washington Univ., Seattle (USA). Dept. of Physics). pp 368-371 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The second layer of $^3$He on a Grafoil substrate appears to behave similarly to the first layer, with the exception that none of the ordered phases exist. Two-dimensional imperfect gas behaviour is seen throughout the second layer while completion is marked by formation of a low density solid. Studies are presently continuing into the evolution of bulk behaviour in the $^3$He system.

**5969 Similarity of rotons and polarons near the threshold of emission.** Whitfield, G. (Pennsylvania State Univ., University Park (USA). Dept. of Physics). pp 154-156 of In Low temperatue physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

It is pointed out that an analogy exists between rotons and polarons near the threshold of emission. The authors intend to apply some of the variational wavefunctions developed in the polaron problem to the roton case. It is clear that arguments similar to Pitaevskii's (for the roton emission threshold) apply to the polaron.

**5970 Dynamic structure factor of $^4$He at 4.2 K.** Woods, A.D.B.; Svensson, E.C.; Martel, P. (Atomic Energy of Canada Ltd., Chalk River, Ontario). pp 187-190 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The technique of inelastic scattering of thermal neutrons has been used to determine the dynamic structure factor, $S(Q,\omega)$ of liquid $^4$He at 4.2 K in the range $0.20 <= Q <= 2.60 A^{-1}$ where $\hbar Q/2\pi$ is the neutron momentum transfer and $\hbar\omega/2\pi$ the energy transfer. The static structure factor, S(Q), and the static susceptibility, chi(Q), were determined from appropriate integrations over $S(Q,\omega)$.

**5971 Dilute solutions of $^3$He in $^4$He: mass and spin diffusion.** Yaniv, A.; Disatnik, Y. (Tel Aviv Univ. (Israel). Dept. of Physics and Astronomy). pp 345-347 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In their study of spin diffusion in the dilute superfluid $^3$He—$^4$He solutions, Husa et al found that, in the limit of a very low $He^3$ concentration and not too low temperature, the spin diffusion coefficient (D/sub s/) is equal to the coefficient of mass diffusion (D) as measured by Ptukha. As the two coefficients are not the same in general, this result is quite interesting. In the following it is shown, using the kinetic theory of the solutions, that under the conditions mentioned here, D/sub s/ should indeed be equal to D. Some qualitative arguments are presented and then a brief outline of the main steps and results of the formal derivation is given.

**5972 Neutron scattering study of elementary excitations in liquid helium-3.** Skold, K.; Pelizzari, C.A.; Kleb, R.; Ostrowski, G.E. (Solid State Science Division, Argonne National Laboratory, Argonne, Illinois 60436), *Phys. Rev. Lett.*; 37: No. 13, 842-845(27 Sep 1976).

The neutron inelastic scattering function of liquid helium-3 at 0.015 K has been measured for wave vectors in the range 0.8 $A^{-1}<$ or $=q<$ or $=2.2$ $A^{-1}$. For $q<1.4$ $A^{-1}$, the scattering function contains two peaks. The peak at lower energy is due to spin-fluctuation scattering in the particle-hole region while the peak at higher energy is identified to be the zero sound mode. By comparing the measured structure factor with the x-ray structure factor, the spin-dependent scattering cross section and the corresponding structure factor are determined. (AIP)

## PARTICLE INTERACTIONS AND PROPERTIES - EXPERIMENTAL

### ELECTROMAGNETIC INTERACTIONS

*REFER ALSO TO CITATION(S) 5618, 5624, 5625, 6003*

**5973 Measurement of differential cross sections for radiative pion-proton capture in the second resonance region.** Weiss, A.J.; Blasberg, D.J.; Comiso, J.C.; Haddock, R.P.; Nefkens, B.M.K.; Verhey, L.J.; Zeller, M.B. (California Univ., Los Angeles (USA)); Crowe, K.M.; Fainberg, A.; Truoel, P. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.). *Nucl. Phys., B;* **101**: No. 1, 1-18(22 Dec 1975).

Differential cross-section measurements for $\pi^-$pyieldsγn, consisting of three angular distributions at 618, 676 and 718 MeV/c, and the energy dependence at theta tilde /sub γ/ =90° for seven incident pion momenta between 502 and 888 MeV/c, are presented. The data qualitatively support recent multipole analyses. Agreement with the Scheffler et al. results for the inverse reaction, γnyields$\pi^-$p, using a ($\pi^-$-recoil p) coincidence technique is good excluding a large violation of time reversal invariance. The agreement with γnyields$\pi^-$p data obtained using the R($\pi^-/\pi^+$) ratio technique or a deuterium bubble chamber is only qualitative.

**5974 Photoproduction experiments at Fermilab.** Peoples, J. (Fermi National Accelerator Lab., Batavia, Ill. (USA)); Lee, W. *Comments Nucl. Part. Phys.;* 6: No. 3, 83-86(Jan 1976).

The history of the use of high energy photons as a tool for the exploration of nuclear and subnuclear structure is briefly summarised, together with mention of suitable accelerators. One of the most important discoveries was the central role played by vector mesons, a family of short-lived hadrons having the same quantum numbers as the photon, in subnuclear structure. Two basic techniques that have been employed at Fermilab for producing high energy photon beam are described, and some significant physics results that have been obtained using what is termed the 'wide band' photon beam are mentioned, including photo production of a new particle J/psi. Problems yet to be explored using high energy photon beams are also indicated. There is also a proposal to produce polarised beams.

**5975 Inclusive pion electroproduction at large p/sub T/.** Browman, A.; Hanson, K.M.; Holmes, S.D.; Kline, R.V.; Larson, D.; Pipkin, F.M.; Raither, S.W.; Silverman, A. (Laboratory for Nuclear Studies, Cornell University, Ithaca, New York 14853). *Phys. Rev. Lett.*; 37: No. 11, 651-655(13 Sep 1976).

We report measurements of the inclusive electroproduction reaction epyieldse$\pi^+$X for pions produced at 90degree in the virtual-photon-proton center-of-mass system. Data are presented at the ($W$,$Q^2$) points (2.2 GeV, 1.2 GeV$^2$), (2.2, 3.6), (2.65, 1.2), (2.65, 2.0), (2.65, 2.8), (2.65, 3.6), (3.1, 1.2), and (3.1, 2.0). The invariant structure function is studied as a function of W, $Q^2$, x/sub T/, p/sub T/$^2$, and the square of the invariant undetected mass. (AIP)

## WEAK INTERACTIONS

**5976 (BNL—21584) Study of the decay K$^0$/sub L/ yields $\pi e\nu$.** Hill, D.G.; Sakitt, M.; Snape, G. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 26p. (CONF-760719—10). Dep. NTIS $4.00.

From 18. international conference on high energy physics; Tbilisi, Union of Soviet Socialist Republics (USSR) (15 Jul 1976).

Results are reported from a Dalitz plot analysis of 17750 K$^0$/sub e3/ candidates obtained in an experiment designed to study both the semileptonic and 3$\pi$ decay modes of the K$^0$/sub L/ with high efficiency across the Dalitz plot.

**5977 Study of neutral current interactions in the Brookhaven 7-ft. bubble chamber.** Cazzoli, E.G.; Cnops, A.M.; Connolly, P.L.; Louttit, R.I.; Murtagh, M.J.; Palmer, R.B.; Samios, N.P.; Tso, T.T.; Williams, H.H. (Brookhaven National Lab., Upton, N.Y. (USA)). pp 239-256 of In La physique du neutrino a haute energie. Paris; Centre National de la Recherche Scientifique (1975).

From International colloquium on high energy neutrino physics; Paris, France (18 Mar 1975).

Preliminary results are reported on the observation of neutrino induced neutral current interactions in the 7-ft. bubble chamber at Brookhaven National Laboratory. The data used were obtained from the analysis of a hydrogen exposure of 62,000 pictures and of a deuterium exposure of 68,000 pictures. The neutral current to charge current ratio for multipion final states is measured to be 0.23+-0.08.

**5978 Neutral currents studies in the ANL 12' bubble chamber.** Hyman, L.G. (Argonne National Lab., Ill. (USA)). pp 183-203 of In La physique du neutrino a haute energie. Paris; Centre National de la Recherche Scientifique (1975).

From International colloquium on high energy neutrino physics; Paris, France (18 Mar 1975).

Neutral-current events were isolated in the channels neutrino protonyieldsneutrino proton $\pi^0$, neutrino protonyieldsneutrino neutron $\pi^+$, neutrino neutronyieldsneutrino proton $\pi^-$, and neutrino neutronyieldsneutrino K$^0$-short-lived $\Lambda^0$, using the ANL 12-foot $H_2$ bubble chamber filled with hydrogen and deuterium. The neutral current sample is compared to the corresponding charged current interactions. Background reactions which contribute to these channels were carefully studied and it is concluded that the neutral-current signal can be isolated. The Weinberg-Salam gauge model is in good agreement with the data.

**5979 Observation of elastic antineutrino-proton scattering.** Cline, D.; Entenberg, A.; Kozanecki, W.; Mann, A.K.; Reeder, D.D.; Rubbia, C.; Strait, J.; Sulak, L.; Williams, H.H. (Department of Physics, Harvard University, Cambridge, Massachusetts 02138). *Phys. Rev. Lett.*; 37: No. 11, 648-651(13 Sep 1976).

We have observed 22 events of the process anti $\nu$pyieldsanti $\nu$p with a background expectation of 8 events. The neutral-current-to-charged-current ratio $\sigma$ (anti $\nu$pyieldsanti $\nu$p)/$\sigma$ (anti $\nu$pyields$\mu^+$ n) is measured to be 0.2 +- 0.1 for $0.3<q^2<0.9$ (GeV/c)$^2$, where -$q^2$ is the square of the four-momentum transfer to the proton. When combined with our previous measurement of $\nu$pyields$\nu$p, this yields a ratio $\sigma$ (anti $\nu$pyields$\nu$p)/$\sigma$ ($\nu$pyields$\nu$p) =0.4 +- 0.2, where the error is statistical, suggesting that a purely vector, neutral, hadronic current is unlikely. (AIP)

## STRONG BARYON-INDUCED INTERACTIONS

**5980 Hadron production at 0.8 mrad by 300 GeV protons incident on a thick aluminium target.** Aubert, B.; Benvenuti, A.; Cline, D.; Coffin, T.; Diamond, R.; French, R.; Ford, W.T.; Imlay, R.; Koester, L.; Koizumi, G. (Harvard Univ., Cambridge, Mass. (USA). Dept. of Physics; Illinois Univ., Urbana (USA). Dept. of Physics; Michigan Univ., Ann Arbor (USA). Dept. of Physics; Pennsylvania Univ., Philadelphia (USA). Dept. of Physics; Wisconsin Univ., Madison (USA). Dept. of Physics; Fermi National Accelerator Lab., Batavia, Ill. (USA)). pp 385-396 of In La physique du neutrino a haute energie. Paris; Centre National de la Recherche Scientifique (1975).

From International colloquium on high energy neutrino physics; Paris, France (18 Mar 1975).

The Fermilab muon beam was used as a double-bend spectrometer for measuring $\pi^{+-}$, $K^{+-}$, proton and antiproton hadronic production, Cherenkov counters being used for particle identification. Measurements were made at 0.8mrad with 300GeV protons hitting an aluminum target.

**5981 Charged particle multiplicities in 100 GeV/c anti pp interactions.** Ansorge, R.E.; Bust, C.P.; Carter, J.R.; Neale, W.W.; Rushbrooke, J.G. (Cambridge Univ. (UK). Cavendish Lab.); Moore, C.; Raja, R.; Voyvodic, L.; Walker, R.J. (National Accelerator Lab., Batavia, Ill. (USA)); Morris, W. *Phys. Lett., B;* 59: No. 3, 295-302(10 Nov 1975).

Results are presented on the topological cross sections obtained for antiproton-proton interactions from an exposure of the Fermilab 30-inch bubble chamber to a 100 GeV/c negative beam enriched in anti p's. The anti pp inelastic cross section is found to be sigma/sub inel/ = 34.6+-0.4 mb, and the average inelastic charged particle multiplicity to be $<n> = 6.74+-0.05$.

**5982 The structure of the forward elastic cross section in (10—14) GeV range.** Carnegie, R.K.; Cashmore, R.J.; Davier, M.; Leith, D.W.G.S.; Walden, P.; Williams, S.H. (Stanford Linear Accelerator Center, Calif. (USA)). *Phys. Lett., B;* 59: No. 3, 313-316(10 Nov 1975).

The logarithmic slope of the differential cross section for $K^{+-}$p elastic scattering at 10 and 14 GeV, and for $\pi^{+-}$p and $p^{+-}$p at 10 GeV has been measured. Rich structure is observed in the forward slope for all processes, which is well accounted for by the properties of a peripheral exchange amplitude for the nonexotic reactions, and by a peripheral component of the diffractive amplitude as clearly seen in the exotic processes, $K^+$p and pp.

**5983 Difference between anti pp and pp topological cross sections up to 100 GeV/c.** Rushbrooke, J.G.; Ansorge, R.E.; Bust, C.P.; Carter, J.R.; Neale, W.W. (Cambridge Univ. (UK). Cavendish Lab.); Moore, C.; Raja, R.; Voyvodic, L.; Walker, R.J. (National Accelerator Lab., Batavia, Ill. (USA)); Morris, W. *Phys. Lett., B;* 59: No. 3, 303-307(10 Nov 1975).

New 100 GeV/c anti pp data are used to find moments of the difference between the anti pp and pp topological cross sections. The mean multiplicity for annihilations at 100 GeV/c is estimated to be 9.06 +- 0.56, and the value of the quantity $<n>/D$ to be 2.75 +- 0.33. It is shown that R/sub n/ = [sigma/sub n/(anti pp) - sigma/sub n/(pp)]/sigma/sub n/(pp) appears at 100 GeV/c to have acquired an asymptotic form, R/sub n/ = s/sup $-\alpha/\beta$/sup n/, with $\alpha$ and $\beta$ constant.

**5984 Stability of the forward multiplicity ratios for p-p and p-aluminum interactions at 28.5 GeV/c.** Gutay, L.J.; Laasanen, A.T.; Ezell, C.; Schreiner, W.N.; Turkot, F. (Physics Department, Purdue University, West Lafayette, Indiana 47907). *Phys. Rev. Lett.*; 37: No. 8, 468-471(23 Aug 1976).

We observe in the laboratory system that within a $\theta$=20degree cone around the incident proton direction, the ratio of the average charged multiplicity for proton-aluminum interactions to that for proton-proton interactions is approximately 1 and is independent of missing mass and the transverse momentum of the trigger proton. (AIP)

**5985 Comparison of the shapes of $\pi^+$p and pp diffraction peaks from 50 to 175 GeV/c.** Anon(Fermi National Accelerator Laboratory, Batavia, Illinois 60510). *Phys. Rev. Lett.*; 37: No. 9, 548-550(30 Aug 1976).

The ratio of $\pi^+$p to pp elastic scattering is found to be smoothly varying over the range -t=0.03 to 0.4 GeV$^2$. It is well fitted by a single exponential, indicating the forward behavior must be quite similar for the two reactions. (AIP)

**5986 Inclusive $\pi^0$ production by high-energy protons.** Carey, D.C.; Johnson, J.R.; Kammerud, R.; Ritchie, D.J.; Roberts, A.; Sauer, J.R.; Shafer, R.; Theriot, D.; Walker, J.K.; Taylor, F.E. (Fermi National Accelerator Laboratory, Batavia, Illinois 60510). *Phys. Rev., D;* 14: No. 5, 1196-1216(1 Sep 1976).

Measurements of the cross section for the reaction p + p yields $\pi^0$ + anything have been completed. The data cover a range of incident proton energies 50—400 GeV, $\pi^0$ transverse momenta 0.3—4 GeV/c, and laboratory angles 30—275 mrad. The experiment was performed using the internal proton beam at the Fermi National Accelerator Laboratory. A lead-glass counter was used to detect photons from the decay of $\pi^0$'s produced by collisions in thin targets of hydrogen or carbon. Tables of the measured cross sections are presented. (AIP)

**5987 I=3/2 πN resonances in the 1900-MeV region.** Cutkosky, R.E.; Hendrick, R.E.; Kelly, R.L. (Carnegie-Mellon University, Pittsburgh, Pennsylvania 15213). *Phys. Rev. Lett.;* **37**: No. 11, 645-648(13 Sep 1976).

We report results of a πN partial-wave analysis for I=3/2 resonances observed in the 1900-MeV region: $F_{35}(1885)$, $F_{37}(1945)$, $P_{31}(1940)$, and $D_{35}(1925)$. The $D_{35}(1925)$ is difficult to accommodate in conventional baryon models; we discuss an alternative model having such a state. (AIP)

**5988 Limits on charmed-particle production in proton-nucleus collisions at 400 GeV/c.** Bintinger, D.; Lundy, R.A.; Yovanovitch, D.D.; Akerlof, C.W.; Alley, P.; Koltick, D.; Loveless, R.L.; Meyer, D.I.; Thun, R.; Ditzler, W.R.; Finley, D.A.; Loeffler, F.J.; Shibata, E.I.; Stanfield, K.C. (Fermi National Accelerator Laboratory, Batavia, Illinois 60510). *Phys. Rev. Lett.;* **37**: No. 12, 732-735(20 Sep 1976).

We have searched for the charmed and other new particles by measuring the hadron pair mass spectra in proton-nucleus collisions at 400 GeV/c. Results are presented for $\pi^-K^+$, $\pi^+K^-$, and $\pi^+\pi^-$ pairs in the mass region from 1.5 to 4.0 GeV/$c^2$. No evidence for narrow resonances was found. The sensitivity of the search varied from 2 x $10^{-30}$ $cm^2$ at GeV/$c^2$ to 5 x $10^{-32}$ $cm^2$ at 4 GeV/$c^2$. Experimental checks were provided by the observation of a clean J/psi (3.1) yields$\mu^+\mu^-$ signal. (AIP)

**5989 Inclusive μ-pair production at 150 GeV by $\pi^+$ mesons and protons.** Anderson, K.J.; Henry, G.G.; McDonald, K.T.; Pilcher, J.E.; Rosenberg, E.I.; Branson, J.G.; Sanders, G.H.; Smith, A.J.S.; Thaler, J.J. (Enrico Fermi Institute, University of Chicago, Chicago, Illinois 60637). *Phys. Rev. Lett.;* **37**: No. 13, 799-802(27 Sep 1976).

We report the measurements of the inclusive μ-pair production by 150-GeV protons and $\pi^+$ mesons on beryllium. Absolute cross sections as well as the Feynman-x and P/sub T/ dependence are presented in the mass region between 0.211 and 3.5 GeV/$c^2$. Upper limits are also given for the inclusive production of eta and rho' (1600) mesons. (AIP)

**5990 Absolute differential cross section measurements for proton-proton elastic scattering at 647 and 800 MeV.** Willard, H.B.; Anderson, B.D.; Baer, H.W.; Barrett, R.J.; Bevington, P.R.; Anderson, A.N.; Willmes, H.; Jarmie, N. (Case Western Reserve University, Cleveland, Ohio 44106). *Phys. Rev., C;* **14**: No. 4, 1545-1553(Oct 1976).

Absolute differential cross sections for elastic proton—proton scattering have been measured in the center-of-mass angular interval from 20° to 90° at 647 and 800 MeV with overall uncertainties of +-(3—10)% and +-(3—5)%, respectively. The data at 800 MeV are the most accurate so far reported at that energy. Comparison is made to earlier measurements and contemporary phase-shift analyses. (AIP)

## STRONG MESON-INDUCED INTERACTIONS

*REFER ALSO TO CITATION(S) 5973, 5980, 5982, 5985, 5989*

**5991** (BNL—21583) **Measurement of the differential cross section of $K^+n$ yields $K^0p$ at $K^+$ momenta of 0.7, 0.8, and 0.9 GeV/c.** Sakitt, M.; Skelly, J.; Thompson, J. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 18p. (CONF-760719—9). Dep. NTIS $3.50.

From 18. international conference on high energy physics; Tbilisi, Union of Soviet Socialist Republics (USSR) (15 Jul 1976).

The cross section and differential cross section for $K^+n$ yields $K^0p$ charge-exchange scattering was measured at 700 to 900 MeV/c, and the $K^0$ decay lifetime was also measured. Comparisons were made with partial-wave-analysis predictions. (JFP)

**5992** (BNL—21585) **BNL multiparticle spectrometer (MPS) and an observation of a peak in the anti $K^0\pi^+\pi^-$ effective mass at 1700 MeV.** Foley, K.J.; Etkin, A.; Goldman, J.H. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 10p. (CONF-760719—11). Dep. NTIS $3.50.

From 18. international conference on high energy physics; Tbilisi, Union of Soviet Socialist Republics (USSR) (15 Jul 1976).

The MPS is based on a large magnet, 6 ft. x 15 ft. x 4 ft. high, at 10 kG field. The detector consists of magnetostrictive and capacitive readout spark chambers with proportional wire chambers and scintillation counters for triggering. The performance of the system is described, and results from a high statistics study of the reaction $K^-p$ yields anti $K^0pi^+\pi^-n$ at 6 GeV/c are presented. A statistically significant (6 standard deviations) peak was observed in the anti $K^0pi^+pi^-$ effective mass at 1700 MeV.

**5993 Measurement of the real part of the forward scattering amplitude in $K^{+-}p$ elastic scattering at 10.4 and 14 GeV/c.** Carnegie, R.K.; Cashmore, R.J.; Davier, M.; Leith, D.W.G.S.; Richard, F.; Schacht, P.; Walden, P.; Williams, S.H. (Stanford Linear Accelerator Center, Calif. (USA)). *Phys. Lett., B;* **59**: No. 3, 308-312(10 Nov 1975).

The differential cross section for $K^{+-}p$ elastic scattering has been measured in the very low t region ($0.003<t<0.2$ GeV$^2$) in a wire chamber spectrometer experiment at 10.4 and 14 GeV/c. The interference effect observed between the Coulomb and the nuclear interaction has been used to determine $\alpha$, the ratio of real to imaginary part of the forward scattering amplitude. At 10.4 GeV/c the authors measure $\alpha(K^+p)$=-0.21+-0.06 and $\alpha(K^-p)$=0.08+-0.04, and at 14 GeV/c, $\alpha(K^+p)$=-0.13+-0.03 and $\alpha(K^-p)$=0.00+-0.04 in agreement with the predictions of dispersion theory calculations.

**5994 Invariant effects in the reaction $\pi^-C^{12}$yieldsmp +X, m> or =2, at 4 and 40 GeV/c.** Azimov, S.A.; Igamberdyev, K.R.; Lutfullaev, S.L.; Usmanov, T.M.; Yuldashev, A.A.; Yuldashev, B.S. (Physico-technical Institute of the Uzbek Academy of Sciences). *JETP Lett. (USSR) (Engl. Transl.);* **23**: No. 4, 42-43(20 Feb 1976).

The inclusive spectra of the protons in the reaction $\pi^-C^{12}$y ieldsmp+X, m> or =2, coincide at 4 and 40 GeV. This result does not contradict scale invariance in hadron-nuclear interactions. (AIP)

**5995 Charm threshold in electron-positron annihilation.** Lane, K.; Eichten, E. (Laboratory of Nuclear Studies, Cornell University, Ithaca, New York 14853). *Phys. Rev. Lett.;* **37**: No. 8, 477-480(23 Aug 1976).

Available data on new mesons discovered at SPEAR are sufficient to determine the spectrum of low-lying charmed mesons and to provide a complete description of the threshold structure of R in the framework of the charmonium model. A number of simple tests are proposed to confirm the charm interpretation. (AIP)

**5996 Production of n and n-bar in $\pi^-p$ and $\pi^-$Ne collisions at 200 GeV/c.** Fortney, L.R.; Goshaw, A.T.; Lamsa, J.W.; Loos, J.S.; Robertson, W.J.; Walker, W.D. (Physics Department, Duke University, Durham, North Carolina 27706). *Phys. Rev., D;* **14**: No. 5, 1190-1195(1 Sep 1976).

The processes $\pi^-p$ yields (neutral hadron) + X and $\pi^-$Ne yields (neutral hadron) + X at 200 GeV/c have been studied and compared by examining the secondary collisions of neutral hadrons in a bubble chamber. The results are satisfactorily explained in terms of n and n-bar production. The observed n-bar production rates are 0.10 +- 0.04 per inelastic $\pi^-p$ collision and 0.07 +- 0.03 per inelastic $\pi^-$Ne collision. No evidence for new long-lived neutral hadrons is found. (AIP)

**5997 Average charged multiplicity in $\pi^-$+pyields$\pi$/sub fast/$^-$ +X at 147 GeV/c and comparison with other reactions.** Anon(NONE). (I 1380Kp). *Phys. Rev. Lett.;* **37**: No. 12, 736-739(20 Sep 1976).

The average charged multiplicity, <n/sub x/>, has been determined for $\pi^-$+pyields$\pi$/sub fast/$^-$+X at 147 GeV/c and is found to increase linearly with absolute t as well as lnM/sub x/$^2$. The coefficient of the lnM/sub x/$^2$ term is approximately equal to that for other reactions, but the absolute value of <n/sub x/> is significantly smaller even when it is analyzed in terms of the energy available. This result is discussed in the framework of a simple model. (AIP)

**5998 Structure in $K^-$-nucleon total cross sections below 1.1 GeV/c.** Carroll, A.S.; Chiang, I.; Kycia, T.F.; Li, K.K.; Mazur, P.O.; Michael, D.N.; Mockett, P.M.; Rahm, D.C.; Rubinstein, R. (Brookhaven National Laboratory, Upton, New York 11973). *Phys. Rev. Lett.;* **37**: No. 13, 806-809(27 Sep 1976).

Total cross sections of $K^-p$ and $K^-d$ have been measured between 410 and 1070 MeV/c with high statistical precision. In addition to the well known Λ (1520), Λ (1820), and Σ (1769), we confirmed the presence of the Λ (1692) and the Σ (1670). We have also observed several structures which could be Y* resonances: Λ (1646), Λ (1735), Σ (1583), Σ (1608), Σ (1633), and Σ (1715). (AIP)

**5999 Reaction $^2$H(d,n)$^3$He as a calibrated polarized neutron source and the analyzing power of $^4$He(n,n)$^4$He from 20 to 30 MeV.**

Lisowski, P.W.; Walter, R.L.; Ohlsen, G.G.; Hardekopf, R.A. (Duke University and Triangle Universities Nuclear Laboratory, Durham, North Carolina 27706). *Phys. Rev. Lett.*; 37: No. 13, 809-812(27 Sep 1976).

Results are reported for the zero-degree analyzing power and longitudinal vector polarization transfer coefficient values of the reaction $^3$H(d,n)$^4$He. These data allowed a calibration of the neutron polarization to an absolute accuracy of +- 2%. The analyzing power of $^4$He was measured using the calibrated neutron beam for E/sub n/ in the range 20 to 30 MeV. The results of the $^4$He analyzing power measurements are compared to phase-shift predictions as well as other data for $^4$He(n,n)$^4$He and $^4$He(p,p)$^4$He in the same energy region. (AIP)

## PARTICLE INTERACTIONS AND PROPERTIES - THEORETICAL

### GENERAL

**6000 f dominance and final-state counting in multiperipheral cluster models.** Finkelstein, J.; Koplik, J. (Department of Physics, Columbia University, New York, New York 10027). *Phys. Rev., D;* 14: No. 5, 1437-1444(1 Sep 1976).

We discuss several problems associated with the formulation and use of multiperipheral cluster models and the closely related Reggeon-loop expansion in dual models. We present a method which unambiguously and uniquely counts final states, and combine it with conventional factorization to obtain a t-channel integral equation with Regge-pole solutions. These correctly counted solutions are used to estimate the error induced by various incorrect counting schemes. We then consider the relation between Reggeon and Pomeron poles, assuming the latter originate from crossed-loop or cylinder diagrams, and emphasize the tacit assumptions needed to obtain f-dominated Pomeron couplings. We find a Pomeron intercept of about 0.8. (AIP)

**6001 Use of a relativistic oscillator model to explain the seagull effect and anomalous charged-lepton production.** Osborne, L.S. (Department of Physics and Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139). *Phys. Rev. Lett.*; 37: No. 11, 661-663(13 Sep 1976).

A relativistic oscillator model gives an expression for meson emission as a function of the fractional de-excitation $\alpha$, $k^2$(transverse), and the meson mass. From this, a form for $<k^2$(transverse)> in terms of z is derived; it agrees with electroproduction experiments. The same expression predicts single-photon and, thereby, anomalous charged-lepton pair production. (AIP)

### ELECTROMAGNETIC INTERACTIONS

*REFER ALSO TO CITATION(S) 6007, 6008, 6011, 6012*

**6002 Scaling violation in electroproduction at large $\omega'$.** Gounaris, G.J.; Manesis, E.K. (Ioannina Univ. (Greece)); Verganelakis, A. (European Organization for Nuclear Research, Geneva (Switzerland)). *Phys. Lett., B;* 59: No. 4, 391-396(24 Nov 1975).

The GVD predictions for scaling violation in electroproduction at $\omega'$> approximately 5 are presented and agree with data. The effects of charm are included and found negligible in the $\omega'$-$q^2$ domain of present experiments, but appreciable at higher $\omega'$ and (or) $q^2$.

**6003 Compton scattering on the proton at low and medium energies.** Baranov, P.S.; Fil'kov, L.V. (P. N. Lebedev Physics Institute, Academy of Sciences of the USSR, Moscow). *Sov. J. Particles Nucl. (Engl. Transl.);* 7: No. 1, 42-69(Jan 1976).

The experimental and theoretical investigations into the elastic scattering of $\gamma$ rays on protons at low and medium energies are reviewed. Dispersion relations and dispersion sum rules for the $\gamma$N scattering amplitudes are constructed and analyzed. The sign of the $\pi^0$yields2$\gamma$ decay amplitude is found. The experimental $\gamma$p scattering cross sections at $\gamma$ energies approximately-less-than100 MeV are used to determine the coefficients of the electric and magnetic polarizability of the proton. (AIP)

**6004 Radiative transitions of low-lying positive-parity mesons.** Babcock, J.; Rosner, J.L. (School of Physics and Astronomy, University of Minnesota, Minneapolis, Minnesota 55455). *Phys. Rev., D;* 14: No. 5, 1286-1298(1 Sep 1976).

Experiments soon to be performed, such as Coulomb dissociation of hadrons and $e^+e^-$ yields $e^+e^-$ + hadrons, will be able to measure radiative decays of mesons with J/sup PC/ = $2^{++}$, $1^{++}$, $0^{++}$, and $1^{+-}$. In advance of these experiments, predictions are made for rates and angular distributions in such processes as $A_2$ yields $\pi\gamma$, $f_0$ yields rho$\gamma$, and $f_0$ yields $\gamma\gamma$. These predictions are based only on vector dominance and single-quark selection rules, but will permit the first tests of such hypotheses for excited mesons. Results include: (a) relatively large partial widths for $f_0$ yields $\gamma$rho and $f_0$ yields $\gamma\gamma$: $\Gamma$ ($f_0$ yields $\gamma$rho) $\cong$ 1.5 MeV and $\Gamma$ ($f_0$ yields $\gamma\gamma$) $\cong$ 8 keV; (b) the suppression of $\lambda = 0, +- 1$ decays relative to $\lambda = +- 2$ for these processes; (c) relative phases for helicity amplitudes in these processes, implying definite angular distributions in $\gamma\gamma$ yields $f_0$ yields $\pi\pi$ and $f_0$ yields $\gamma$rho yields $\gamma\pi^+\pi^-$; and (d) the nearly complete suppression of $\gamma\gamma$ couplings of $0^{++}$ qq-bar states. (AIP)

**6005 Parton fragmentation model for inclusive pion spectra in electron—positron annihilation.** Suzuki, M.; Wada, W.W. (Lawrence Berkeley Laboratory and Department of Physics, University of California, Berkeley, California 94720). *Phys. Rev., D;* 14: No. 5, 1299-1302(1 Sep 1976).

The inclusive pion spectra in $e^+e^-$ annihilation are analyzed in the parton fragmentation model with nonvanishing transverse momenta and with heavy partons. The nonscaling phenomena in the small-x region are explained quite satisfactorily in this model. (AIP)

### WEAK INTERACTIONS

*REFER ALSO TO CITATION(S) 6013*

**6006 Testing the muon-number conservation law in nu-bar/sub mu/+$e^-$ interactions at high energies.** Chang, C.Y.; Rosen, S.P. (University of Maryland, College Park, Maryland 20742). *Phys. Rev. Lett.*; 37: No. 8, 471-473(23 Aug 1976).

We propose to test the validity of the multiplicative muon-number conservation law by comparing the quasielectric reactions nu-bar/sub mu/+$e^-$yields$\mu^-$+nu-bar/sub e/ and $\nu$/sub mu/+$e^-$yields$\mu^-$+$\nu$/sub e/ at approximately-greater-than400 GeV. We note that the measured electron spectrum in muon decay places strong constraints on the effective Lagrangian for the nu-bar/sub mu/-induced process. (AIP)

**6007 Inclusive hadron spectrum in $e^+e^-$ annihilation as a test for the production and decay of heavy leptons.** Gaemers, K.J.F.; Raitio, R. (Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305). *Phys. Rev., D;* 14: No. 5, 1262-1268(1 Sep 1976).

The production and subsequent decay into a neutrino and hadrons of a heavy lepton in $e^+e^-$ colliding beams gives a contribution to the inclusive hadron spectrum sd$\sigma$/dx. We calculate this contribution, assuming the usual V - A structure for the weak hadronic current and assuming that the "hadronic" decays of the heavy lepton are dominated by the $\pi$, rho, $A_1$, and rho' mesons. Owing to the decay into a single pion and a neutrino, the inclusive energy spectrum of hadrons has a distinct maximum. The position of this maximum is directly related to the heavy-lepton velocity. Experimental determination of the position of this maximum will therefore determine the heavy-lepton mass. Our calculation also shows that the inclusive hadron spectrum decreases with increasing x less rapidly than the total measured inclusive hadron spectrum. Measuring the spectrum of a hadron in $e^+e^-$ yields hadron + e ($\mu$) + anything and determining the position of the maximum offers a test for the existence of heavy leptons and a way of determining their mass. (AIP)

**6008 Dimuon production in an unconfined-heavy-fermion model of the new particles.** Sidhu, D.P.; Smith, J.; Vermaseren, J.A.M. (Brookhaven National Laboratory, Upton, New York 11973). *Phys. Rev., D;* 14: No. 5, 1269-1275(1 Sep 1976).

We attempt to understand the gross features of neutrino-induced dimuon-production data in the framework of an unconfined-heavy-fermion model of the new particles. We calculate the total cross section and spectra for single-$F^+$ production via the reaction $\nu$/sub $\mu$/ + p yields $\mu^-$ + $\nu$/sub F/ + $F^+$ + X. Assuming that the $F^+$ has a leptonic decay mode $F^+$ yields $\mu^+$ + $\nu$/sub $\mu$/ + nu-bar/sub F/, we conclude that the model fails to fit the present experimental data because the cross section is far too small and the production mechanism is not sufficiently inelastic. (AIP)

**6009 Possibility of observing neutral-current decays of psi (3.1).** Rich, J.; Winn, D.R. (High Energy Physics Laboratory, Harvard University, Cambridge, Massachusetts 02138). *Phys. Rev., D;* 14: No. 5, 1283-1285(1 Sep 1976).

We discuss the feasibility of measuring the rate of the weak neutral-current decay, psi (3.1) yields $\nu\nu$-bar. An experimental program is sketched. (AIP)

### STRONG INTERACTIONS, GENERAL

**6010 (RL—75-176) Geometrical aspects of high energy elastic scattering.** Barger, V.; Phillips, R.J.N. (Societe Nationale des

Petroles d'Aquitaine (SNPA), 64 - Pau (France). Lab. de Chimie Physique; Wisconsin Univ., Madison (USA). Dept. of Physics; Science Research Council, Chilton (UK). Rutherford Lab.). Dec 1975. Contract E(11-1)-881. 13p. Dep. NTIS $3.50.

New Fermilab π/sup +-/p, K/sup +-/p, p/sup +-/p elastic scattering data from 50 to 200 GeV/c are discussed. Each channel seems to approach geometrical scaling, with crossing-related pairs differing only in radial scale. This implies a simple crossover formula, and peripherality for the imaginary parts of crossing-odd amplitudes. The data are consistent with a single universal function describing all channels, with adjustable opacity and radial scales; however, this function must be close to the eikonal or unabsorbed overlap function, and cannot be the elastic amplitude nor the complete overlap function.

**6011 Electromagnetic mass splitting of hadrons in the quark model.** Lichtenberg, D.B. (Physics Department, Indiana University, Bloomington, Indiana 47401). *Phys. Rev., D;* 14: No. 5, 1412-1419(1 Sep 1976).

Assuming that electromagnetic interactions between quarks are Coulomb plus magnetic-moment interactions, we derive an equality and several inequalities among the hadron electromagnetic mass splittings, including two inequalities which relate mass splittings of strange baryons and mesons. None of the mass relations we derive is in contradiction with the present experimental data. (AIP)

**6012 Mass spectra of the new particles and the psi' radiative decays.** Mac Gregor, M.H. (Lawrence Livermore Laboratory, Livermore, California 94550). *Phys. Rev., D;* 14: No. 5, 1463-1466(1 Sep 1976).

A previously published light-quark elementary-particle model contains an excitation series for generating high-mass narrow-width meson resonances. Two terms in this excitation series accurately correspond to the psi(3095) and psi'(3684) resonances; these two terms also lead to quantitatively correct values for the $chi_1$, P/sub c/, and $chi_2$ radiative decay levels of the psi'(3684). Several other new particle states also correspond to terms in this light-quark excitation series. (AIP)

## STRONG INTERACTIONS, BARYON NO. 0

**6013 (COO—1195-377) New results in muon-production of hadrons at high energies.** Anderson, H.L.; Bharadwaj, V.K.; Booth, N.E. (Illinois Univ., Urbana (USA). Dept. of Physics). 1976. 14p. (CONF-760719—13). Dep. NTIS $3.50.

From 18. international conference on high energy physics; Tbilisi, Union of Soviet Socialist Republics (USSR) (15 Jul 1976).

Improved measurements of the hadronic structure function, F(x'), and charge ratio are presented for the inelastic scattering of muons by protons and neutrons. Correlation data between the leading and successive hadrons is also presented.

**6014 Color-symmetry breaking and the new mesons.** Capps, R.H. (Physics Department, Purdue University, West Lafayette, Indiana 47907). *Phys. Rev., D;* 14: No. 5, 1433-1436(1 Sep 1976).

It is assumed that the psi(J) and psi' mesons at 3.1 and 3.7 GeV are color excitations, and that color symmetry is broken badly. A simple symmetry-breaking mechanism leads to the prediction of a total of nine vector and nine pseudoscalar mesons in the 3—4 GeV region. This is in striking contrast with the predictions of both the standard color-excitation model and the charm model of the psi(J) and psi'. An estimate is made of the mass of a predicted baryon-resonance multiplet. Several other predictions of the model are compared with those of the charm model and with experiment. (AIP)

**6015 Energy dependence of the rho Regge trajectory.** Finkelstein, J.; Koplik, J. (Columbia University, New York, New York 10027). *Phys. Rev., D;* 14: No. 5, 1467-1469(1 Sep 1976).

If recent ideas on the renormalization of the Pomeron due to particle-production thresholds are coupled with the exchange-degeneracy constraints of the dual topological expansion, it follows that the nonvacuum Reggeons must also be renormalized. We apply this result to the rho trajectory. (AIP)

**6016 Mass differences of charmed hadrons.** Lane, K.; Weinberg, S. (Laboratory of Nuclear Studies, Cornell University, Ithaca, New York 14853). *Phys. Rev. Lett.;* 37: No. 11, 717-719(13 Sep 1976).

The mass difference m ($D^+$)-m ($D^0$) of the charmed pseudoscalar meson doublet is estimated as about 6.7 MeV, as compared with the value 15 MeV given by De Rujula, Georgi, and Glashow. Mass differences are also estimated for charmed baryons. (AIP)

## STRONG INTERACTIONS, BARYON NO. 1

*REFER ALSO TO CITATION(S) 6014*

**6017 (RLO—2041-147) High transverse momentum meson production with meson and proton beams.** Teper, M. (Oregon Univ., Eugene (USA). Inst. of Theoretical Science). 1975. Contract AT(45-1)-2041. 10p. (OITS—75-31). Dep. NTIS $3.50.

The production in $\pi^-$p collisions of $\pi^0$s at high p/sub perpendicular/ and 90° in the c.m. is calculated within a previously advanced parton-free model. The results are consistent with preliminary data, but differ from parton model predictions by orders of magnitude. Some further predictions of the model are also given.

**6018 Description of exclusive processes in the Reggeized one-pion-exchange model.** Ponomarev, L.A. (Institute of Theoretical and Experimental Physics, Moscow). *Sov. J. Particles Nucl. (Engl. Transl.);* 7: No. 1, 70-93(Jan 1976).

The model of Reggeized one-pion exchange is applied to exclusive reactions with low multiplicity. A definite variant of the model (the OPER model) is applied to reactions in which one or two pions are produced in πN and NN collisions. Practically all the characteristics of these reactions are described quantitatively in a model with fixed parameters values: the energy dependence of the cross sections, the mass distributions for systems of two and three particles, the momentum-transfer distributions, the cms angular distributions of πN and ππ pairs, and the appearance of near-threshold peaks in the πN, ππ, πππ, and Nππ systems (the Deck effect). (AIP)

**6019 Determination of the J/psi(3100)—nucleon total cross section using modulus dispersion relations.** Hendrick, R.E.; Rittenberg, V.; Sanda, A.I. (Rockefeller University, New York, New York 10021). *Phys. Rev., D;* 14: No. 5, 1311-1313(1 Sep 1976).

Using the energy dependence of photoproduction data from Cornell, Fermilab, and SLAC, we calculate the phase of the forward elastic J/psi(3100)—N scattering amplitude by applying modulus dispersion relations. The total cross section thus obtained suggests that the J/psi(3100) is a hadron. A possible threshold due to production of a new quantum number is also discussed. Similar analysis is carried out for the phip forward elastic amplitude. (AIP)

**6020 Two related questions: Centrifugal barriers and the spin of the Ω⁻.** Mac Gregor, M.H. (Lawrence Livermore Laboratory, Livermore, California 94550). *Phys. Rev., D;* 14: No. 5, 1323-1334(1 Sep 1976).

The centrifugal-barrier concept of nuclear physics is commonly assumed to apply also to elementary-particle physics; e.g., SU(3) calculations of decay coupling constants include explicit barrier factors. However, this assumption may be incorrect, for both theoretical and experimental reasons--theoretically, nuclear rotations are adiabatic and nuclear decays have a small energy release, whereas elementary-particle rotations are highly nonadiabatic and particle decays have an enormous energy release; experimentally, nuclear resonances get narrower with increasing spin values, whereas hadron resonances get systematically broader--and this hadron result holds uniformly for all values of baryon number and strangeness. By assuming that baryon resonances each contain three spin-1/2 quarks, and by studying the spin, width, and mass characteristics of these resonances, we arrive at a two-fold experimental difference between rotationless (l = 0) and rotational (l > 0) baryon excitations: (1) The l = 0 excitations are narrower (in contrast to the situation in nuclear physics); (2) the l = 0 mass values are quantized, whereas the l > 0 mass values are not. The quantization of the l = 0 baryon levels shows a correlation between masses and spin values S; in particular, narrow S = 3/2 levels appear at about 1530 MeV, and S = 1/2 levels appear at about 1670 MeV. This suggests that the Ω⁻, with a mass of about 1670 MeV, has spin S/sub Ω/ = 1/2 rather than the SU(3)-mandated value S/sub Ω/ = 3/2. These results underscore the importance of carrying out a direct measurement of spin of the Ω⁻; such a measurement appears to be experimentally feasible. (AIP)

## STRONG INTERACTIONS, BARYON NO. GREATER THAN 1

*REFER ALSO TO CITATION(S) 6018*

**6021 Absorptive effects in the diffractive dissociation of nucleons.** Berger, E.L.; Pirila, P. (Argonne National Lab., Ill. (USA)). *Phys. Lett., B;* 59: No. 4, 361-366(24 Nov 1975).

Absorptive effects are found to be important in diffraction dissociation. For ppyields(n$\pi^+$)p and npyields(p$\pi^-$)p, at small excitation mass, a significant dip structure is created in the production momentum transfer distribution dsigma/dt dM near

t=0.3(GeV/c), in agreement with data from Fermilab and the Cern-ISR The mass-slope correlation, seen in the data, is also reproduced. Most other distributions are affected much less by absorption.

**6022 Analysis of radial scaling in single-particle inclusive reactions.** Taylor, F.E.; Carey, D.C.; Johnson, J.R.; Kammerud, R.; Ritchie, D.J.; Roberts, A.; Sauer, J.R.; Shafer, R.; Theriot, D.; Walker, J.K. (Northern Illinois University, DeKalb, Illinois 60115). *Phys. Rev., D;* 14: No. 5, 1217-1242(1 Sep 1976).

An analysis of an extensive sample of the world's data has been performed to test the hypothesis of radial scaling. We have studied the inclusive reactions p + p yields $\pi^{+-0}$, $K^{+-}$ p or p-bar) + anything to determine the behavior of the invariant cross section as a function of p/sub perpendicular/, x/sub R/ = E*/E*/sub max/, the radial scaling variable, and s. The data cover a range in p/sub perpendicular/ from 0.25 to ~ 6.0 GeV/c and a range in $\sqrt{s}$ from 3.0 to 63 GeV. For small x/sub R/ and all available p/sub perpendicular/ the single-particle inclusive cross sections for the reactions studied scale to a good approximation for all $\sqrt{s}$, even down to the kinematic threshold. For large x/sub R/, the single-particle inclusive cross sections for increasing $\sqrt{s}$ show a rapid approach to the scaling limit from above. In these cases the scaling limit is always approached by $\sqrt{s} \cong 10$ GeV. Thus, data for all particles to a good approximation exhibit radial scaling at all available p/sub perpendicular/ and x/sub R/ over the CERN ISR energy range. A comparison of radial scaling with Feynman scaling is given. It is shown that in the Feynman case the cross sections for small x/sub parallel/ (x/sub parallel/ = p*/sub parallel//p*/sub max/) approach their scaling limit from below, and that the approach to the scaling limit is slower than is exhibited for the case of small x/sub R/. The systematic differences among the inclusive cross sections of various particles are discussed in the range of $\sqrt{s}$ where radial scaling has been shown to be valid. In particular, the p/sub perpendicular/ and x/sub R/ distributions of E $d\sigma/dp^3$ are examined. (AIP)

**6023 Slope of pp elastic scattering at small momentum transfer.** Goulianos, K. (Rockefeller University, New York, New York 10021). *Phys. Rev., D;* 14: No. 5, 1445-1448(1 Sep 1976).

The pp differential elastic scattering cross sections at high energies and small momentum transfer are obtained from a phenomenological analysis using the measured total cross sections and the ratios of the real to the imaginary part of the forward nuclear scattering amplitude. Shrinkage and the observed "break" in the slope are correctly described for all incident momenta in the range 5 < or approx. = p/sub lab/ < or approx. = 2000 GeV/c. (AIP)

**6024 Contribution of muon pairs to the yield of single prompt muons.** Anderson, K.J.; Henry, G.G.; McDonald, K.T.; Pilcher, J.E.; Rosenberg, E.I.; Branson, J.G.; Sanders, G.H.; Smith, A.J.S.; Thaler, J.J. (Enrico Fermi Institute, University of Chicago, Chicago, Illinois 60637). *Phys. Rev. Lett.;* 37: No. 13, 803-806(27 Sep 1976).

Using data from our recent experiment on inclusive $\mu$-pair production by 150-GeV/c protons on beryllium, we have calculated the contribution of muon pairs to the yield of single prompt muons. We find, both at 90degree in the center-of-mass system and in the forward direction, that the resulting single-muon cross sections are in reasonable agreement with the existing measurements for which only one muon is detected. (AIP)

## PARTICLE INVARIANCE PRINCIPLES AND SYMMETRIES

*REFER ALSO TO CITATION(S) 6033*

### GENERAL

*REFER ALSO TO CITATION(S) 6130*

**6025 Dynamical symmetry breaking of U(N) -symmetric gauge theory in the 1/N expansion.** Kang, J.S. (Department of Physics, Brandeis University, Waltham, Massachusetts 02154). *Phys. Rev., D;* 14: No. 6, 1587-1601(15 Sep 1976).

A gauge theory with U(N) symmetry is studied in the large-N limit to all orders in the scalar self-coupling, and to lowest nontrivial order in the gauge coupling. Unlike the 1/N expansion of the scalar field theory, the effective potential is found to be always real, although it can be mutiple-valued. Furthermore, there is a region in the coupling-constant space where symmetry is broken spontaneously involving two separate phase transitions, one of the first kind and one of the second kind. This phenomenon persists for arbitrarily small (finite) gauge coupling as a genuine feature of the 1/N expansion, exhibiting much more of the nonlinear structure of the complete theory than found in ordinary perturbation expansions. A comparison is made between the spontaneous symmetry breaking found in the 1/N expansion and that of other symmetry-breaking schemes, which are of the Goldstone, Higgs, or Coleman-Weinberg type. Here the vector—scalar-boson mass ratio, m/sub V/ $^2$/m/sub S/ $^2$, is of O ($g^2$), which is contrasted with Higgs and Coleman-Weinberg mechanisms for which m/sub V/ $^2$/m/sub S/ $^2$ is of O (1) and O ($g^{-2}$), respectively, where g is the gauge coupling. (AIP)

**6026 SU(3) -symmetry breaking and partial conservation of axial-vector current in the constituent-quark basis.** Fuchs, N.H. (Physics Department, Purdue University, West Lafayette, Indiana 47907). *Phys. Rev., D;* 14: No. 6, 1709-1710(15 Sep 1976).

The axial-vector-current divergences do not transform under SU(3) as they naively appear to transform. The consequences of this observation are drawn, correcting and extending an earlier paper of the author. (AIP)

### APPLICATIONS TO ELECTROMAGNETIC AND WEAK INTERACTIONS

**6027 Gauging a pseudosymmetry.** Gates, S.J. Jr. (Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139). *Phys. Rev., D;* 14: No. 5, 1357-1366(1 Sep 1976).

We consider extending the gauge group of an earlier model of Dicus, Teplitz, and Young by taking advantage of the existence of a possible pseudosymmetry. We retain the requirement of duality as was initially proposed. In addition, we propose that spin-zero exchange is the reason for the $\Delta I = 1/2$ rule among the hadrons and the anomalous strength of the weak nonleptonic decays. The model is anomaly-free and offers some interesting ideas as to the role that spin-zero exchange might play in the weak interaction. We also find a "superweak" interaction where abs. value of $\Delta S = 2$ and neutral, strangeness-changing transitions are allowed in second order, but such processes are suppressed relative to ordinary weak processes. (AIP)

### APPLICATIONS TO STRONG INTERACTIONS

*REFER ALSO TO CITATION(S) 6014*

**6028 Radiative decays as tests of the symmetries of the psi particles.** Cahn, R.N.; Chanowitz, M.S. (National Accelerator Lab., Batavia, Ill. (USA)). *Phys. Lett., B;* 59: No. 3, 277-280(10 Nov 1975).

The success of the Okubo-Iizuka-Zweig rule for decays of psi and psi' suggests that the radiative decays psiyieldsγ + hadrons should be dominated by intermediates like psiyieldspsi' + hadrons. This mechanism is consistent with experimental data which show GAMMA(psiyieldsrho$^0\pi^0$) and GAMMA(psiyieldsetaγ) to be comparable. If all psi-like particles are isoscalar, GAMMA(psiyieldsπ$^0\gamma$) should be very small. If all psi-like particles are SU(3) singlets, GAMMA(psiyieldseta'γ)(GAMMA(psi yieldsetaγ) should be large. Substantial violation of the predictions would be circumstantial evidence for the existence of non-singlet new quarks.

**6029 Zweig's Rule violation, SU(3) character of the decay of the new particles, and pole dominance picture.** Bolzan, J.F.; Geer, K.A.; Palmer, W.F.; Pinskt, S.S. (Fermi National Accelerator Lab., Batavia, Ill. (USA)). *Phys. Lett., B;* 59: No. 4, 351-356(24 Nov 1975).

The decays psi'yieldspsiππ and psiyieldsωepsilon are studied in the framework of Zweig Rule violations via SU(4) pole dominance. The SU(3) character of the decay of the psi is discussed in the same model. Using results of the purely hadronic decays, the cascade transition rates psi'yieldsepsilonsub(c)+γ and epsilonsub(c)yieldspsi+γ are calculated and compared to recent experimental data.

## FIELD THEORY

*REFER ALSO TO CITATION(S) 6025, 6026*

**6030 Particle behaviour in aesthetic field theory.** Muraskin, M. (Stanford Linear Accelerator Center, Calif. (USA)). *Int. J. Theor. Phys.;* 13: No. 5, 303-316(Aug 1975).

Lecture given at Stanford Linear Accelerator Center, Jul 1974.

The principles of aesthetic field theory are reviewed and the latest results obtained from computer studies of the equations.

**6031 The algebraic approach in axiomatic relativistic quantum theory.** Todorov, T.S. (Institute of Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, Sofia). *Sov. J. Particles Nucl.* (*Engl. Transl.*); 7: No. 1, 94-115(Jan 1976).

The results of the algebraic approach in axiomatic relativistic quantum theory are reviewed. (AIP)

**6032 Longitudinal vector field Hamiltonians.** Bolsterli, M. (Theoretical Division, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545). *Phys. Rev., D;* 14: No. 4, 945-954(15 Aug 1976).

A canonical transformation is used to study the Hamiltonian for the interaction of a Dirac field with a longitudinal vector field. The transformed Hamiltonian has a lower degree of formal divergence of its perturbation series than does the untransformed one. Its semirelativistic approximant has no divergences; hence, variational methods can be applied. The single-particle and infinite-uniform-matter cases are treated by variational methods in the semirelativistic approximation. (AIP)

**6033 Mixing of internal and space-time symmetries.** Huang, K.; Stump, D.R. (Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139). *Phys. Rev. Lett.;* 37: No. 9, 545-548(30 Aug 1976).

In a general Yang-Mills theory with self-interacting boson and/or fermion source fields, it is shown that the angular momentum operator is J=$J_0$+$(2\pi)^{-1}$Q/sub a/Phi-arrow-right/sub a/, where $J_0$ is the free-field angular momentum (i.e., that for zero gauge coupling constant), Q/sub a/ is the total charge, corresponding to the internal symmetry index $\alpha$, and Phi/sub a//sub k/ is the total flux of del x A/sub a/ along the x/sub k/ direction, in the gauge delxA/sub a/=0. (AIP)

**6034 Group theory for Feynman diagrams in non-Abelian gauge theories.** Cvitanovic, P. (Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305). *Phys. Rev., D;* 14: No. 6, 1536-1553(15 Sep 1976).

A simple and systematic method for the calculation of group-theoretic weights associated with Feynman diagrams in non-Abelian gauge theories is presented. Both classical and exceptional groups are discussed. (AIP)

**6035 Properties of three position operators constructed from free spin-1/2 fields.** Durand, B. (Institute for Advanced Study, Princeton, New Jersey 08540). *Phys. Rev., D;* 14: No. 6, 1554-1567(15 Sep 1976).

We consider three position operators constructed from free spin-1/2 fields. The first operator is the field-quantized form of the Dirac position operator. The momentum-space form of this operator has terms corresponding to single pair production and single pair destruction. The second and third operators are constructed to eliminate the pair terms. The second operator has no obvious nonfield analog, but the third is the field-quantized form of the Newton-Wigner position operator. We discuss several properties of these three operators, including the velocities, matrix elements, the algebra with respect to the Poincare generators, covariance, and the self-commutativity of the operator densities at spacelike-separated points. Our conculsion is that the first, Dirac-type operator has the best combination of properties. (AIP)

**6036 Collective phenomena in λphi⁴ field theory treated in the random-phase approximation.** Cooper, F.; Guralnik, G.S.; Kasdan, S.H. (Theoretical Division, Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico 87544). *Phys. Rev., D;* 14: No. 6, 1607-1626(15 Sep 1976).

We investigate λphi⁴ theory in the random-phase approximation as a prototypic model for understanding the formation of bound states (here 2-meson bound states) and the nature of the effective interaction between such states. We give the random-phase approximation a functional-derivative interpretation which allows us to determine the effective expansion parameter of the random-phase approximation to be (λ/sub R/ $^2$/N) D/sub R/($q^2$), where D/sub R/($q^2$) is the propagator of the collective mode. The field theory in this approximation has both mass and coupling-constant renormalization, and we derive expressions for unrenormalized and renormalized 2-, 4-, and 6-point functions for the original scalar field, and determine the 4-point function for bound-state—bound-state scattering as well as the effective coupling between bound states. We show the relation between the random-phase approximation and the O(N) model for large N and prove that without single-field symmetry breaking there is a range renormalized coupling constant where there is no ghost. (AIP)

**6037 Strong-coupling field theories. II. Fermions and gauge fields on a lattice.** Drell, S.D.; Weinstein, M.; Yankielowicz, S. (Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305). *Phys. Rev., D;* 14: No. 6, 1627-1647(15 Sep 1976).

This paper (the second in a series) reports our recent progress in the study of strong-coupling quantum field theories on a lattice. In particular we study theories involving fermions and gauge fields and pay special attention to the peculiar problems encountered when one formulates theories of fermions on a lattice. It is unique to our approach that we preserve local chiral symmetry and at the same time correctly count the number of fermionic states. We demonstrate how our formalism works with the lattice Thirring and Schwinger models, whose continuum limits are solvable in one space and one time dimension. We show in the strong-coupling limit that these theories are equivalent to a Heisenberg antiferromagnetic chain. We also discuss briefly some general features of non-Abelian gauge theory of quarks and gluons in three space and one time dimension. The most interesting results we have to report at this stage are as follows: (i) The only "gauge-invariant states" which remain at low mass in the limit of very strong gauge coupling have the quantum number of physical hadrons. (ii) The resulting "effective strong-coupling" theory preserves the full chiral symmetry of the exact theory [SU(3) x SU(3) if we introduce three flavors of quarks each with three colors] and describes a theory of "massless bare hadrons" interacting with one another through a quark interchange mechanism of finite strength. (AIP)

**6038 Flux tubes, monopoles, and the magnetic confinement of quarks.** Wyld, H.W.; Cutler, R.T. (Department of Physics, University of Illinois, Urbana, Illinois 61801). *Phys. Rev., D;* 14: No. 6, 1648-1659(15 Sep 1976).

A numerical study is made of the gauge-field model of magnetic confinement. The nonlinear differential equations describing a flux tube are solved by a relaxation method. Particular attention is paid to the boundary conditions at the center of the flux tube. We also study numerically the 't Hooft monopole and a flux tube of finite length, i.e., a quark-antiquark pair a finite distance apart. (AIP)

**6039 Nonexistence of spherically symmetric monopoles with multiple magnetic charge.** Weinberg, E.J.; Guth, A.H. (Columbia University, New York, New York 10027). *Phys. Rev., D;* 14: No. 6, 1660-1662(15 Sep 1976).

We show that in a spontaneously broken SU(2) gauge theory there are no field configurations with magnetic charge >1 which are both spherically symmetric and of finite energy. (AIP)

**6040 Quantum corrections to classical confinement.** Chodos, A.; Klein, A. (Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139). *Phys. Rev., D;* 14: No. 6, 1663-1666(15 Sep 1976).

We study two models involving charged scalar fields in one space dimension, which have baglike properties at the classical level. Following conventional renormalization procedures, we find that either the first model becomes a free theory or else its spectrum becomes unbounded below depending on how one renormalizes. The second model also becomes a free theory with a particular choice of renormalization. In no case are we able to retain the classical confinement, although we can restore interactions by adding suitable counterterms to the Hamiltonian. (AIP)

**6041 Models with quark confinement and linear trajectories without parity doubling.** Chu, S.; Kaus, P. (University of California, Riverside, California 92506). *Phys. Rev., D;* 14: No. 6, 1681-1685(15 Sep 1976).

We consider simple dynamic models where the quarks satisfy the Dirac equation with a confining potential. We show that if the confining potential is a Lorentz scalar, the solutions to the Dirac equation satisfy the MacDowell symmetry. We discuss the slope of Regge trajectories in these models and show that in order for the trajectory to be linear (in $s = E^2$) the potential must have a specific j dependence, which produces a cut in j of the type first proposed by Carlitz and Kislinger. In other words, the same mechanism which produces linear trajectories in the first place also produces the cut which removes the parity partners. The specific j dependence is expected in "bag" models, as well as relativistic soliton solutions. (AIP)

**6042 Practical lower bound for scalar fields on a lattice.** Pearson, R.B. (Fermi National Accelerator Laboratory, Batavia, Illinois 60510). *Phys. Rev., D;* 14: No. 6, 1686-1689(15 Sep 1976).

A simple lower bound on the ground-state energy density is derived for a scalar field on a lattice. This bound is applied to phi⁴ theory in one space and one time dimension and the results compared with available upper bounds. (AIP)

**6043** **Global ground state of phi$^6$ theory in three dimensions.** Townsend,. P.K. (Department of Physics, Brandeis University, Waltham, Massachusetts 02154). *Phys. Rev., D;* **14**: No. 6, 1715-1721(15 Sep 1976).

We show that the effective potential of three dimensional phi$^6$ theory to leading order in the 1/N expansion may have a minimum at phi$^2$ = 0 even though the classical potential has a maximum. When this happens the effective potential is double-valued near phi$^2$ = 0. We discuss some interesting consequences of this but show that provided the phi$^6$ coupling is of normal strength the global minimum of the effective potential remains at nonzero phi$^2$. This confirms earlier results on the spontaneous breaking of the O(N) symmetry of this theory. (AIP)

## SCATTERING THEORY

**6044** (COO—3130TA-331) **Eikonal field theory description of interacting pomerons.** Fried, H.M. (CEA Centre d'Etudes Nucleaires de Saclay, 91 - Gif-sur-Yvette (France). Service de Physique Theorique; Brown Univ., Providence, R.I. (USA). Dept. of Physics). 1976. Contract E(11-1)-3130. 9p. (CONF-760669—1). Dep. NTIS $3.50.

From Seminar on geometric models of the elementary particles; Osaka, Japan (7 Jun 1976).

Starting from an underlying field theory in Eikonal approximation, interacting Pomerons are produced by retaining those Feynman graphs that correspond to self-energy and related radiative corrections. Multiple Reggeon t-channel thresholds may be viewed in a simple s-channel field theory framework, while the degree of s-channel unitarity required depends upon the spin content of the underlying field theory and the classes of permitted processes. An approximate Eikonal calculation suggests how restricted triple-Pomeron interactions can serve to remove the bare Pomeron, and substitute an alternate asymptotic expression for o/sub TOT/.

**6045** (RLO—2041-148) **N-loop expansion of the Reggeon calculus.** Dash, J.W.; Harrington, S.J. (Oregon Univ., Eugene (USA). Inst. of Theoretical Science). Aug 1975. Contract AT(45-1)-2041. 9p. (OITS—75-2(Rev.)). Dep. NTIS $3.50.

The technique known in solid state physics as the n-loop expansion is applied to calculate the critical indices of the phi$^3$ Gribov Reggeon calculus directly in two transverse dimensions. Infrared pathologies of the massless theory require the calculation to be done in the infinite momentum limit of the massive theory. For n = 1 the results are close to those of the epsilon-expansion in O(epsilon). For n = 2 the $\beta$ function has no zero, analogously to the case in solid state physics. Use of a Pade approximant for $\beta$ yields sigma/sub tot/ approximately equals(ln s)$^{0.27}$ at infinity, close to the O(epsilon$^2$) result.

**6046** **Magnitude of three-pomeron vertex.** Abramovskii, V.A. (Physics Institute, Georgian Academy of Sciences). *JETP Lett. (USSR) (Engl. Transl.);* **23**: No. 4, 39-41(20 Feb 1976).

It is shown that when the first two orders of perturbation theory are taken into account it is impossible to obtain a small bare three-pomeron vertex r that agrees with the experimental data. Inclusion of the third order leads probably to r/r/sub eff/≅4. (AIP)

# NUCLEAR PHYSICS

**6047** **Reaction list for charged-particle-induced nuclear reactions Z = 1 to Z = 98 (H to Cf), October 1974 to January 1976.** McGowan, F.K.; Milner, W.T. (Oak Ridge National Lab., TN). *At. Data Nucl. Data Tables;* **18**: No. 1, 1-136(Jul 1976).

This Reaction List for charged-particle-induced nuclear reactions has been prepared from the journal literature for the period from October 1974 through January 1976. Each published experimental paper is listed under the target nucleus in the nuclear reaction with a brief statement of the type of data in the paper. The nuclear reaction is denoted by A(a,b)B, where M/sub a/ greater than or equal to (one nucleon mass). There is no restriction on energy. Nuclear reactions involving mesons in the outgoing channel are not included. Theoretical papers which treat directly with the analysis of nuclear reaction data and results are included in the Reaction List.

## NUCLEAR PROPERTIES AND REACTIONS, A=1-5, THEORETICAL

### MASS, ABUNDANCE, AND BINDING ENERGY

**6048** (RLO—1388-317) **D-state effects in transfer reactions.** Knutson, L.D. (Washington Univ., Seattle (USA)). 1975. Contract E(45-1)-1388. 10p. (CONF-750829—14). Dep. NTIS $3.50.

From 4. international symposium on polarization phenomena in nuclear reactions; Zurich, Switzerland (25 Aug 1975).

A review is given of the effects of the D state in (d(pol),p) reactions on nuclei with A equal to or greater than 12. The scope is limited to transfer reactions on nuclei for which conventional distorted wave theories apply. It appears that tensor analyzing power measurements may be of some practical importance in studying these effects. (JDF)

### NUCLEAR REACTIONS AND SCATTERING

**6049** **Noneikonal approach to the scattering of hadrons from nuclei. II. Proton and pion scattering from D, $^3$He and $^4$He (k/sub l/approximately-greater-than1 GeV/c).** Gurvitz, S.A.; Alexander, Y.; Rinat, A.S. (Weizmann Institute of Science, Rehovot, Israel). *Ann. Phys. (N.Y.);* **98**: No. 2, 346-389(Jun 1976).

A previously formulated noneikonal theory for hadron-nucleus scattering valid for all angles is applied to p and $\pi$ scattering on the lightest targets (k/sub l/approximately-greater-than1 GeV/c). When the required input is known, calculated differential cross sections agree well with experiments out to medium angles, far beyond the region of previous analyses. In the case of pA scattering at k/sub l/=1.2 GeV/c at which momentum some parameters in the elementary amplitudes F/sub x//sub N/ are badly known, limits on the values have been obtained by demanding simultaneous agreement between theory and data for several targets. Generally speaking the agreement evidences the existence of some major corrections to the eikonal amplitude, namely, propagator off-shell and nucleon recoil effects. Inclusion of the latter primarily affects the single scattering amplitude, which may dominate the large-q$^2$ cross section if F/sub x//sub N/ (like F/sub nu//sub nu/) itself rises with q$^2$. The calculation of pD and p$^4$He cross sections requires knowledge of body form factors S/sub A/ often unknown for large q$^2$. Consistency requirements for angular distributions at several k/sub l/ lead to a conjectured large-q$^2$ behavior of S/sub A/(q). In the case of the D the conjecture has been largely confirmed by a recent measurement of the electric form factor. The agreement leaves little room for NN* components in the D as heretofore derived from pD scattering. We speculate that in general, reasonable estimates for nuclear form factors out to very large q$^2$ may be obtained from hadron-nucleus scattering data with existing facilities. Since higher q$^2$ values can be reached in hadron-nucleus than in eA scattering, the former may well provide the first tests for predicted scaling of nuclear form factors. (AIP)

## NUCLEAR PROPERTIES AND REACTIONS, A=1-5, EXPERIMENTAL

### ENERGY LEVELS AND TRANSITIONS

**6050** (ANL-Trans—1070) **Study of the states P/sub 3/2/ and P/sub 1/2/ of the nuclei $^5$He and $^5$Li by diffusions n + $^4$He and p + $^4$He.** Kraus, L.; Linck, I. Translated from *Nucl. Phys., A;* **A224**: 45-60(1974). 28p. Dep. NTIS $4.00.

Differential cross sections were measured for $^4$He + p elastic scattering in the angular range from 30 to 165° and at incident energies ranging from 0.5 to 3 MeV. These data and previously existing cross section and polarization data are analyzed in the framework of the Humblet-Rosenfeld S-matrix theory. The characteristics of the P/sub 3/2/ and P/sub 1/2/ $^5$Li levels are deduced. A similar analysis is performed for the $^4$He + n elastic scattering and spectroscopic characteristics of the mirror nucleus $^5$He P-levels are then deduced. These results seem to be less ambiguous than those of phase shift R-matrix analyses and are in good agreement with nuclear reactions results. The spin-orbit splitting is found to be of the order of 2.1 MeV for the two nuclei. Mass excesses of $^5$He and $^5$Li are found to be 11.275 +- 0.05 MeV and 11.313 +- 0.1 MeV, respectively.

### NUCLEAR REACTIONS AND SCATTERING

*REFER ALSO TO CITATION(S) 5973, 5990, 6050*

**6051 Elastic proton scattering from $^4$He at 0.58 and 0.72 GeV.** Verbeck, S.L.; Fong, J.C.; Igo, G.; Whitten, C.A. Jr. (California Univ., Los Angeles (USA)); Hendrie, D.L.; Terrien, Y.; Perez-Mendez, V. (California Univ., Berkeley (USA). Lawrence Berkeley Lab.); Hoffmann, G.W. (Texas Univ., Austin (USA). Dept. of Physics). *Phys. Lett., B;* **59**: No. 4, 339-342(24 Nov 1975).

The energy spectra of $\alpha$-particles recoiling from a $^4$He gas target bombarded by 0.58- and 0.72-GeV protons have been measured to obtain the differential cross sections for elastic scattering, dsigma/dt, in the region of four-momentum transfer squared, $-t = 0.13—0.55$ (GeV/c)$^2$. The experiment was designed especially to observe the region between the first and second diffraction maxima.

**6052 $\pi^-$He$^4$ and $\pi^-$O$^{16}$ elastic scattering and excitation of the 3$^-$ (6.13 MeV) level of the O$^{16}$ nucleus by $\pi^-$ mesons at 1 GeV/c.** Burgov, N.A.; Vlasov, M.K.; Gerzon, S.A.; Kiselev, Y.T.; Karmanov, V.A.; Man'ko, A.V.; Martem'yanov, A.M.; Terekhov, Y.V.; Ushakov, V.I.; Chukamov, M.M. (Institute of Theoretical and Experimental Physics). *JETP Lett. (USSR) (Engl. Transl.);* **23**: No. 5, 272-276(5 Mar 1976).

We measured the $\pi^-$He$^4$ and $\pi^-$O$^{16}$ elastic scattering cross section for $\pi^-$ mesons with momentum 1.02 GeV/c and the cross section for the excitation of the 3$^-$ (6.13 MeV) level of the O$^{16}$ nucleus in the momentum-transfer interval 0.085—0.145 (GeV/c)$^2$. It was found that the experimental values agree with the results of calculations by the Glauber theory. An indication of a possible difference between the neutron and proton form factors of the transition is obtained. (AIP)

## NUCLEAR PROPERTIES AND REACTIONS, A=6-19 THEORETICAL

*REFER ALSO TO CITATION(S) 6054*

### MASS, ABUNDANCE, AND BINDING ENERGY

*REFER ALSO TO CITATION(S) 6092*

### NUCLEAR REACTIONS AND SCATTERING

**6053 Recoil corrections to elastic electron scattering in the Breit approximation.** Friar, J.L. (Department of Physics, Brown University, Providence, Rhode Island 02912). *Ann. Phys. (N.Y.);* **98**: No. 2, 490-515(Jun 1976).

Recoil corrections to the cross sections for elastic electron scattering from spin-0 nuclei are investigated in the Breit approximation. The form of the scattering amplitude in first- and second-Born approximation is investigated in detail using time-dependent perturbation theory, and it is found that the center-of-mass (CM) frame is particularly convenient to work in. Transformation equations relating the lab and CM frames are developed. Those parts of the second-Born amplitude which correspond to the Breit amplitude are isolated, and the Briet equation with the electromagnetic Breit interaction is investigated in detail. Corrections to the scattering cross sections which are inversely proportional to the nucleus mass (recoil corrections) are calculated. Numerical results are presented for the particular case of $^{16}$O. (AIP)

## NUCLEAR PROPERTIES AND REACTIONS, A=6-19, EXPERIMENTAL

**6054** (RLO—1388-314) **Parity mixing.** Adelberger, E.G. (Washington Univ., Seattle (USA)). 1975. Contract E(45-1)-1388. 8p. (CONF-750829—13). Dep. NTIS $3.50.

From 4. international symposium on polarization phenomena in nuclear reactions; Zurich, Switzerland (25 Aug 1975).

The field of parity mixing in light nuclei bears upon one of the exciting and active problems of physics—the nature of the fundamental weak interaction. It is also a subject where polarization techniques play a very important role. Weak interaction theory is first reviewed to motivate the parity mixing experiments. Two very attractive systems are discussed where the nuclear physics is so beautifully simple that the experimental observation of tiny effects directly measures parity violating (PV) nuclear matrix elements which are quite sensitive to the form of the basic weak interaction. Since the measurement of very small analyzing powers and polarizations may be of general interest to this conference, some discussion is devoted to experimental techniques.

### ENERGY LEVELS AND TRANSITIONS

*REFER ALSO TO CITATION(S) 6058, 6061*

**6055 Experimental study of giant dipole and quadrupole resonances in $^{16}$O.** Buenerd, M.; Martin, P.; de Saintignon, P.; Loiseaux, J.M. (Institut des Sciences Nucleaires, BP 257, 38044 Grenoble Cedex, France). *Phys. Rev., C;* **14**: No. 4, 1316-1319(Oct 1976).

The 20—30-MeV excitation energy region of $^{16}$O was investigated by inelastic scattering of 45 MeV protons and 60 MeV $\alpha$ particles. Both E1 and E2 strengths are present, exhausting, respectively, about 50% and between 16 and 21% of the corresponding energy-weighted sum rule. Microscopic calculations also reproduce angular distributions fairly well. (AIP)

### NUCLEAR REACTIONS AND SCATTERING

*REFER ALSO TO CITATION(S) 6052, 6055, 6073*

**6056** (RLO—1388-306) **Analyzing power for elastic scattering of protons from $^{13}$C.** Trainor, T.A.; Back, N.L.; Bussoletti, J.E.; Knutson, L.D. (Washington Univ., Seattle (USA). Nuclear Physics Lab.). 1975. Contract E(45-1)-1388. 2p. (CONF-750829—11). Dep. NTIS $3.50.

From 4. international symposium on polarization phenomena in nuclear reactions; Zurich, Switzerland (25 Aug 1975).

Measurements of the analyzing power for $^{13}$C + p for proton bombarding energies from 10 MeV to 18 MeV were made in order to examine the suitability of this case for a D-parameter measurement. Excitation curves were obtained at laboratory angles of 30, 50, 70, 110, 130 and 150°. Angular distributions were also measured at a number of energies. Statistical errors are less than 0.01 for all cases. The broad structures in the backward-angle excitation curves indicate significant compound nuclear contributions over the entire energy range. These results indicate that $^{13}$C is not suitable for a depolarization measurement at presently attainable tandem energies. In contrast to the structured backward-angle excitation curves that at theta/sub lab/ = 50° is relatively structure-free. The magnitude of the analyzing power at this angle is large (—0.6 to —0.8) over a broad energy range from 11.5 MeV to 18 MeV. It is suggested that $^{13}$C is a good alternative polarization analyzer in cases where a gas-target analyzer is impractical.

**6057** (RLO—1388-308) **Depolarization in the elastic scattering of 17-MeV protons from $^9$Be.** Baker, M.P.; Blair, J.S.; Cramer, J.G.; Trainor, T.; Weitkamp, W. (Washington Univ., Seattle (USA)). 1975. Contract E(45-1)-1388. 2p. (CONF-750829—8). Dep. NTIS $3.50.

From 4. international symposium on polarization phenomena in nuclear reactions; Zurich, Switzerland (25 Aug 1975).

The measurement of the angular distribution of the depolarization parameter is reported for the elastic scattering of 17-MeV protons from $^9$Be at angles in the range 55 less than theta/sub cm/ less than 165°. The reaction was initiated by a polarized proton beam and the polarization of those protons elastically scattered by the $^9$Be analyzed using a high-resolution, silicon polarimeter. The polarimeter has a measured analyzing power of approximately +0.4 and an efficiency equal to 1-2 x $10^{-5}$ with an intrinsic resolution of 170 keV. Data were taken at scattering angles both left and right of the incident beam and for alternate orientations of the incident spin direction. The latter allows the cancellation of first-order systematic errors.

**6058 Study of T=0 and T=2 giant dipole resonances in $^{14}$N.** Paul, P. (State Univ. of New York, Stony Brook (USA). Dept. of Physics); Kuan, H.S. (Brooklyn Coll., N.Y. (USA)); Warburton, E.K. (Brookhaven National Lab., Upton, N.Y. (USA)). *Nucl. Phys., A;* **254**: No. 1, 1-6(1 Dec 1975).

The reaction $^{13}$C(p,$\gamma$)$^{14}$N was studied over the range of excitation energies from 23 to 33 MeV in $^{14}$N, with emphasis on the transition to the 0$^+$,T=1 state at 2.31 MeV. The 1$^-$,T=0 GDR based on this state was confirmed to be concentrated between 15 and 23 MeV, in agreement with theoretical predictions. However, previous evidence for T=2 resonances near 24 MeV was not confirmed and no evidence was obtained for the T=2 GDR predicted to lie between 25 and 29 MeV.

**6059 Proton polarization in the reactions ($\gamma$,p$\pi^0$) and ($\gamma$,p$\pi^-$) on the $^{12}$C nucleus.** Anan'in, P.S.; Glavanakov, I.V.; Stibunov, V.N. (Nuclear Physics Institute of the Tomsk Polytechnic Institute). *JETP Lett. (USSR) (Engl. Transl.);* **23**: No. 5, 269-272(5 Mar 1976).

Results are presented of the measurement of the energy dependence of the proton polarization in the reactions $(\gamma,p\pi^0)$ and $(\gamma,p\pi^-)$ on $^{12}C$. The measurements were made by registering the pions and protons in coincidence. No strong influence of the interaction in the final state on the proton polarization was observed. The proton polarization in the reaction $(\gamma, p\pi^-)$ agrees with the predictions of Walker's analysis, and no reversal of its sign in the region of the second ($\pi$N) resonance was observed. (AIP)

**6060 New resonances in the low-energy $^{12}C$-$^{12}C$ spectrum.** Erb, K.A.; Betts, R.R.; Hanson, D.L.; Sachs, M.W.; White, R.L.; Tung, P.P.; Bromley, D.A. (Wright Nuclear Structure Laboratory, Yale University, New Haven, Connecticut 06520). *Phys. Rev. Lett.*; 37: No. 11, 670-673(13 Sep 1976).

Angular distributions of transitions to low-lying states in $^{20}Ne$ have been measured for the reaction $^{12}C(^{12}C,\alpha)$ in 62.5-keV steps for 6.5< or =E/sub c.//sub m./<11 MeV. Two new nonstatistical structures are identified at E/sub c.//sub m./=7.71 and 9.84 MeV, with J/sup pi/=4$^+$ and 8$^+$, respectively. These observations support the quasimolecular interpretations of the low-energy structure in the $^{12}C$-$^{12}C$ interaction. (AIP)

**6061 $(\alpha,^2He)$ reaction as a spectroscopic tool for investigating high-spin states.** Jahn, R.; Wozniak, G.J.; Stahel, D.P.; Cerny, J. (Department of Chemistry and Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720). *Phys. Rev. Lett.*; 37: No. 13, 812-816(27 Sep 1976).

A $^2$He detection system has been developed and used to investigate the $(\alpha,^2He)$ reaction at 65 MeV on $^{12}C$, $^{13}C$, and $^{16}O$ targets. Extreme spectroscopic selectivity with preferential population of final states with $(d_{5/2})_4^{2+}$ character was observed. Applications of this experimental technique to the detection of other unbound reaction products are proposed. (AIP)

**6062 Reaction $^{12}C(\gamma,\pi^-)^{12}N$ near the threshold.** Bernstein, A.M.; Paras, N.; Turchinetz, W.; Chasan, B.; Booth, E.C. (Physics Department and Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139). *Phys. Rev. Lett.*; 37: No. 13, 819-822(27 Sep 1976).

The total cross section for the reaction $^{12}C(\gamma,\pi^-)^{12}N$ has been determined by observation of the residual $^{12}N$ radioactivity. The cross section was extracted from the bremsstrahlung excitation function which was measured in the region between 3.6 and 12.6 MeV above the threshold, with one point 33.5 MeV above the threshold. The variation of the measured cross section with energy is far more rapid than is predicted by calculations using the epsilon-arrow-rightxsigma-arrow-right interaction. Even when the full interaction Hamiltonian is used, the experimental cross section rises somewhat more rapidly than predicted. (AIP)

## NUCLEAR PROPERTIES AND REACTIONS, A=20-38, EXPERIMENTAL

### ENERGY LEVELS AND TRANSITIONS

**6063 Isobaric analog impurities from neutron capture and transmission by magnesium.** Weigmann, H.; Macklin, R.L.; Harvey, J.A. (Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830). *Phys. Rev., C;* 14: No. 4, 1328-1335(Oct 1976).

Resonance neutron interactions with the stable isotopes of magnesium were measured at the Oak Ridge Electron Linear Accelerator time-of-flight facility. The transmission of a natural metal sample (78.7% $^{24}Mg$) was measured at 200 m, and capture by natural metal and by enriched isotope samples was measured at 40 m. Twenty-six resonances in $^{24}Mg$ + n up to 1.8 MeV were fitted with Breit—Wigner multilevel parameters. The data were sufficient to assign spin and parity to 19 of these. The capture data were analyzed for resonances up to 850 keV for $^{24}Mg$ + n, 265 keV for $^{25}Mg$ + n (17$^+$ resonances), and 440 keV for $^{26}Mg$ + n (4 resonances). Average capture at stellar interior temperatures was calculated. The $^{24}Mg$ + n data serve to assess the isospin impurities in three isobaric analog states. Three other states exhibit reduced neutron widths, each several percent of the Wigner limit, which may be understood in terms of simple shell model configurations. (AIP)

### NUCLEAR REACTIONS AND SCATTERING

*REFER ALSO TO CITATION(S) 5996, 6063, 6073*

**6064 Runs tests as predictors of intermediate structure in the continuum.** Haglund, R.F. Jr.; Bowen, J.M.; Thompson, W.J. (Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico 87545). *Phys. Rev. Lett.*; 37: No. 9, 553-556(30 Aug 1976).

Chance coherences between S-matrix elements at neighboring compound-nucleus excitation energies in the continuum are shown to generate spurious intermediate structures and statistical correlations in synthetic analyzing-power excitation functions. Hence, certain runs tests may be unreliable predictors of intermediate structure. (AIP)

**6065 Production of $^7Be$, $^{22}Na$, and $^{28}Mg$ from Mg, Al, and $SiO_2$ by protons between 82 and 800 MeV.** Heydegger, H.R.; Turkevich, A.L.; Van Ginneken, A.; Walpole, P.H. (Department of Chemistry, Purdue University, Calumet Campus, Hammond, Indiana 46323). *Phys. Rev., C;* 14: No. 4, 1506-1514(Oct 1976).

Cross sections for the production of $^7Be$, $^{22}Na$, and $^{28}Mg$ from Mg, Al, and $SiO_2$ by protons in the 80 to 800 MeV energy range have been determined by direct foil $\gamma$-ray spectrometry. These nuclides are of interest in several fields of astrophysics, cosmochemistry, and nuclear science. The values obtained are compared with other experimental values and with values predicted using empirical formulas and Monte Carlo methods. A mathematical form for the Al(p, X)$^{22}$Na excitation function above 100 MeV is proposed. (AIP)

## NUCLEAR PROPERTIES AND REACTIONS, A=39-58, THEORETICAL

### MASS, ABUNDANCE, AND BINDING ENERGY

*REFER ALSO TO CITATION(S) 6092*

### ENERGY LEVELS AND TRANSITIONS

**6066 Quantum capillary waves: collective excitations of a Fermi-liquid drop.** Sapershtein, E.E.; Tolokonnikov, S.V.; Fayans, S.A.; Khodel', V.A. (V. I. Kurchatov Institute of Atomic Energy). *JETP Lett. (USSR) (Engl. Transl.);* 23: No. 4, 31-35(20 Feb 1976).

It is shown that low-lying collective states of atomic nuclei belong to a new branch of collective excitations of a Fermi-liquid drop, namely quantum capillary waves. (AIP)

### NUCLEAR REACTIONS AND SCATTERING

*REFER ALSO TO CITATION(S) 6070*

## NUCLEAR PROPERTIES AND REACTIONS, A=39-58, EXPERIMENTAL

### RADIOACTIVE DECAY

**6067 Beta decay of $^{51}Sc$ to states in $^{51}Ti$.** Davids, C.N.; Tabor, S.L.; Norman, E.B.; Pardo, R.C.; Parks, L.A. (Argonne National Laboratory, Argonne, Illinois 60439). *Phys. Rev., C;* 14: No. 4, 1601-1607(Oct 1976).

$^{51}Sc$ was produced with the $^{48}Ca(\alpha, p)^{51}Sc$ reaction at E/sub alpha/ = 18 MeV and pneumatically transferred to a shielded counting area. The $\beta$ decay scheme of $^{51}Sc$ was determined from measurements of the $\gamma$ singles and $\gamma$—$\gamma$ coincidence spectra by using 50-cm$^3$ Ge(Li) detectors. This investigation yielded a more accurate determination of the $^{51}Sc$ half-life (12.4 +- 0.1 s), the observation of previously unknown $\beta$ branches to $^{51}Ti$ levels at 2691, 2731, 2919, 3062, 3237, 3619, 4095, 4186, and 4881 keV, and the assignment of new levels in $^{51}Ti$ at 3062, 4095, and 4186 keV. In addition, the decay scheme provides parity assignments and spin restrictions for a number of states in $^{51}Ti$. (AIP)

### ENERGY LEVELS AND TRANSITIONS

*REFER ALSO TO CITATION(S) 6067*

**6068 Transition rates of high-spin states in $^{54}Co$ and $^{56}Fe$: Possible coexistence of prolate- and oblate-like configurations in $^{56}Fe$.** Sarantites, D.G.; Urbon, J.; Rutledge, L.L. Jr. (Department of Chemistry, Washington University, St. Louis, Missouri 63130). *Phys. Rev., C;* 14: No. 4, 1412-1428(Oct 1976).

The decay properties of the high-spin states in $^{54}Co$ and $^{56}Fe$ have been investigated via the $^{54}Fe(\alpha, pn)^{54}Co^*(\gamma)$ and $^{54}Fe(\alpha, 2p)^{54}Fe^*(\gamma)$ reactions in the energy range 20.4 to 29.5 MeV. From measurements of excitation functions and angular distributions of individual $\gamma$ rays with a Ge(Li)—NaI(Tl) anti-Compton spectrometer, and from $\gamma\gamma$-coincidence experiments, new levels in $^{54}Co$ have been identified at 2282.6 (7$^+_1$), 2371.9 (6$^+_1$), 3638.0 (8$^+_1$), 4180.2 (9$^+_1$), and 5274.6 (10$^+_1$) keV with the deduced J/sup $\pi$/ values in

parentheses. Similarly, levels in $^{56}$Fe have been confirmed at 3388.4 ($6^+_1$), 3755.8 ($6^+_2$), 4700.6 ($7^+_1$), 5255.3 ($8^+_1$), and 5626.8 ($8^+_2$) keV, and the J/sup $\pi$/ values in parentheses have been deduced. The angular distributions in conjunction with the associated attenuation factors were analyzed to yield multipole mixing ratios $\delta$(E2/M1). The mean lifetimes tau of these states were also carefully measured by extrapolation to the detection threshold of the effective mean lifetimes extracted from Doppler-broadened line shapes obtained at four bombardment energies between 20.4 and 29.5 MeV. Values were obtained in $^{56}$Co for the following levels: 2282.6 keV (>2000 fs), 2371.9 keV (60 +- 30 fs), 3638.0 keV ($80^{+40}$/sub -/$_{20}$ fs), 4180.2 keV (590 +- 60 fs), and 5274.6 keV ($60^{+40}$/sub -/$_{20}$ fs); and in $^{56}$Fe values were found for levels at 3388.4 keV (>2000 fs), 3755.8 keV ($180^{+40}/_{-30}$ fs), 4700.6 keV (120 +- 40 fs), 5255.3 keV (500 +- 50 fs), and 5626.8 keV ($100^{+40}_{-20}$ fs). For most of the transitions from the high-spin states in $^{56}$Co and $^{56}$Fe B($\Lambda$) values were obtained. The results for $^{56}$Fe are compared with recent calculations based on the aligned coupling scheme indicating possible coexistence of quasiband structures with prolate- and oblate-like configurations. The results for $^{56}$Co are compared with other recent shell-model calculations and good agreement is observed. (AIP)

### NUCLEAR REACTIONS AND SCATTERING

*REFER ALSO TO CITATION(S) 6068, 6073, 6086*

**6069 $^{58}$Ni(p, p') reaction at 60 MeV: Study of the analyzing power for inelastic excitation of the giant resonance region of the nuclear continuum and of low-lying bound states.** Kocher, D.C.; Bertrand, F.E.; Gross, E.E.; Newman, E. (Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830). *Phys. Rev., C;* 14: No. 4, 1392-1411(Oct 1976).

The analyzing power of the giant resonance region of the nuclear continuum and of low-lying bound states for incident 60-MeV polarized protons has been investigated in the $^{58}$Ni(p, p') reaction. The measurements are compared with collective-model distorted-wave Born-approximation calculations employing a spin—orbit transition potential of the full-Thomas form and optical-model parameters which give a good description of the analyzing power for proton elastic scattering from $^{58}$Ni at 60 MeV. The predicted analyzing powers for the giant quadrupole (E2) resonance at E/sub x/ = 16.5 MeV and for low-lying bound states with J/sup $\pi$/ = $2^+$, $3^-$, and $4^+$ are in qualitative agreement with the measurements for $\theta$/sub lab/ = 15—60°. However, a systematic discrepancy is observed for the quadrupole resonance, where the measurements for $\theta$/sub lab/ = 15—30° are considerably more negative than the calculations. A similar but less pronounced effect is observed for the strongly excited $2^+$ and $3^-$ bound states. Improved fits to the analyzing power for the quadrupole resonance are obtained by reducing the spin—orbit diffuseness parameter or by including an attractive imaginary spin—orbit potential. Analysis of the cross section for a weaker resonance at E/sub x/ = 13.5 MeV indicates an E2 assignment. The analyzing power for the unstructured nuclear continuum above the giant resonance region is A/sub y/ ≅ - 0.05 +- 0.01 at most angles between 15 and 40°. (AIP)

**6070 Absolute cross section of the reaction $^{48}$Ca($^{18}$O, $^{16}$O)$^{50}$Ca.** Feng, D.H.; Tamura, T.; Udagawa, T.; Lynch, J.; Low, K.S. (Department of Physics, University of Texas, Austin, Texas 78712). *Phys. Rev., C;* 14: No. 4, 1484-1487(Oct 1976).

It is shown that the long standing difficulty of very small theoretical cross sections for heavy-ion-induced two-nucleon transfer reactions appears to have been solved, at least for the case of the $^{48}$Ca($^{18}$O, $^{16}$O)$^{50}$Ca reaction. (AIP)

## NUCLEAR PROPERTIES AND REACTIONS, A=59-89, EXPERIMENTAL

### ENERGY LEVELS AND TRANSITIONS

**6071 Evidence for an octupole rotational band in $^{74}$Se.** Piercey, R.B.; Ramayya, A.V.; Ronningen, R.M.; Hamilton, J.H.; Robinson, R.L.; Kim, H.J. (Physics Department, Vanderbilt University, Nashville, Tennessee 37235). *Phys. Rev. Lett.;* 37: No. 9, 496-498(30 Aug 1976).

From in-beam $\gamma$-ray spectroscopy in $^{74}$Se, a negative-parity band to ($11^-$) with rotational properties built on a $3^-$ collective octupole state is established along with the positive-parity (Barrette et al.) yrast band to ($14^+$). The negative-parity band has essentially a constant moment of inertia in sharp constrast to the positive-parity band. This is the first negative-parity band outside those in deformed nuclei with such pure rotational behavior. (AIP)

### NUCLEAR REACTIONS AND SCATTERING

**6072 $^{65}$Cu(p,pn)$^{64}$Cu excitation function in the energy range 13-25 MeV.** Colle, R.; Kishore, R.; Cumming, J.B. (Brookhaven National Lab., Upton, N.Y. (USA)). *J. Inorg. Nucl. Chem.;* 38: No. 1, 23-25(1976).

The excitation function for the $^{65}$Cu(p,pn)$^{64}$Cu reaction from 13 to 25 MeV has been determined. Absolute cross sections were obtained by assaying the 1345.8 keV $\gamma$-ray of the $^{64}$Cu (12.7 hr) with calibrated Ge (Li) spectrometers and by measuring beam intensities with a Faraday cup. The present results which have energy uncertainties of only approximately 0.1 MeV, extend the excitation function for this frequently used beam monitor reaction to energies where it was not well determined previously. The experimental excitation function is also compared with calculations based on a Monte Carlo intranuclear cascade—statistical evaporation model.

**6073 Interlaboratory comparison of spallation-reaction cross sections for iron and copper with 590-MeV protons.** Orth, C.J.; O'Brien, H.A. Jr.; Schillaci, M.E.; Dropesky, B.J. (Los Alamos Scientific Lab., N.Mex. (USA)); Cline, J.E.; Nieschmidt, E.B.; Brodzinski, R.L. *J. Inorg. Nucl. Chem.;* 38: No. 1, 13-17(1976).

Three sets of thin foils of carbon, aluminium, iron, and copper have been simultaneously irradiated with 590-MeV protons. Cross sections of some of the $\gamma$ emitting spallation products from Fe and Cu have been measured independently by members of the three participating laboratories. The results are compared and average cross sections are given. Various sources of error common to such experiments are presented, and the steps taken to minimize them in this work are discussed.

**6074 Spallation of copper by 25-GeV $^{12}$C ions and 28-GeV protons.** Cumming, J.B.; Stoenner, R.W.; Haustein, P.E. (Chemistry Department, Brookhaven National Laboratory, Upton, New York 11973). *Phys. Rev., C;* 14: No. 4, 1554-1563(Oct 1976).

Relative yields of 35 products extending from $^{7}$Be to $^{67}$Ga have been measured for the interaction of 25-GeV (2.1-GeV/amu) $^{12}$C ions with Cu. For purposes of comparison, cross sections of 48 nuclides produced by the irradiation of Cu with 28-GeV protons are also reported. The mass yield curve deduced for the 2.1-GeV/amu $^{12}$C ions is very similar to that reported for 0.28-GeV/amu $^{14}$N, which result implies that there is little energy dependence of target fragmentation cross sections in this energy range where meson production effects in nucleon—nucleon collisions become important. Charge dispersion curves for products with 37 < or = A < or = 64 are the same within errors for $^{12}$C and protons. Compared with 28-GeV protons, the mass yield curve for $^{12}$C shows some favoring of products near the target (possibly due to increased secondary effects). Formation of light fragments such as $^{7}$Be and $^{24}$Na is significantly enhanced, possibly due to highly damaging central collisions of the heavy ions. The results are discussed in terms of the concepts of limiting fragmentation and factorization. (AIP)

### MASS, ABUNDANCE, AND BINDING ENERGY

*REFER ALSO TO CITATION(S) 6092*

## NUCLEAR PROPERTIES AND REACTIONS, A=90-149, EXPERIMENTAL

### ENERGY LEVELS AND TRANSITIONS

*REFER ALSO TO CITATION(S) 6076*

**6075 Levels in $^{144}$Nd from the $^{142}$Nd(d, p) and the $^{146}$Nd(p, t) reactions.** Raman, S.; Auble, R.L.; Ball, J.B.; Newman, E.; Wells, J.C. Jr.; Lin, J. (Oak Ridge National Laboratory, Oak Ridge, Tennessee). *Phys. Rev., C;* 14: No. 4, 1381-1388(Oct 1976).

The energy levels in $^{144}$Nd have been studied by means of the $^{142}$Nd(d, p) reaction at E/sub d/ = 25 MeV and the $^{146}$Nd(p, t) reaction at E/sub p/ = 31 MeV. Angular distributions, values for the transferred angular momenta, and spectroscopic and enhancement factors based on distorted-wave Born approximation calculations have been obtained for ~ 30 states. The (d, p) spectroscopic strengths have been compared with the results of a calculation based on a two-particle—core coupling model. (AIP)

### NUCLEAR REACTIONS AND SCATTERING

*REFER ALSO TO CITATION(S) 6075*

**6076** **Neutron transmission and capture gamma-ray measurements of $^{120}$Sn + n.** Carlton, R.F.; Raman, S.; Harvey, J.A.; Slaughter, G.G. (Middle Tennessee State University, Murfreesboro, Tennessee 37132). *Phys. Rev., C;* **14**: No. 4, 1439-1450(Oct 1976).

Neutron transmission and neutron capture γ-ray measurements have been performed upon 98.4% enriched samples of $^{120}$Sn. The transmission measurements were made at 18- and 80-m neutron flight paths. Neutrons were detected by a $^{6}$Li glass scintillator. Parameters have been obtained for 251 resonances up to 98 keV. From the shapes of the resonances, l-value assignments have been made for 70% of the resonances. Level spacings and strength functions for s- and p-wave neutrons have been obtained. Neutron capture γ rays from 16 resonances, obtained with a Ge(Li) detector, have been utilized to determine the levels in $^{121}$Sn. New spin and parity assignments have been made for many of the levels. Four new levels have been found. The neutron separation energy was determined to be 6170.3 +- 2.0 keV. The $^{121}$Sn level scheme has been compared with those for $^{117}$Sn and $^{119}$Sn to investigate systematic behavior. (AIP)

## NUCLEAR PROPERTIES AND REACTIONS, A=190-219, THEORETICAL

### MASS, ABUNDANCE, AND BINDING ENERGY

*REFER ALSO TO CITATION(S) 6092*

### RADIOACTIVE DECAY

**6077** **Absolute reduced α widths in the lead region.** DeVries, R.M.; Lilley, J.S.; Franey, M.A. (Nuclear Structure Research Laboratory, University of Rochester, Rochester, New York 14627). *Phys. Rev. Lett.;* **37**: No. 8, 481-484(23 Aug 1976).

Elastic and total reaction cross sections for the system α+$^{208}$Pb, $^{209}$Bi are analyzed to obtain a limited set of potentials which are, in turn, used to calculate absolute α widths. Existing shell-model calculations give γ/sub alpha/$^{2}$ values three orders of magnitude smaller: and it is now most unlikely that this discrepancy is due to an uncertainty in the α-nucleus potential. (AIP)

### ENERGY LEVELS AND TRANSITIONS

*REFER ALSO TO CITATION(S) 6066*

### NUCLEAR REACTIONS AND SCATTERING

*REFER ALSO TO CITATION(S) 6077*

## NUCLEAR PROPERTIES AND REACTIONS, A=190-219, EXPERIMENTAL

### RADIOACTIVE DECAY

**6078** **Decay of mass-separated $^{190}$Tl and $^{190}$Hg.** Bingham, C.R.; Riedinger, L.L.; Turner, F.E.; Kern, B.D.; Weil, J.L.; Hofstetter, K.J.; Lin, J.; Zganjar, E.F.; Ramayya, A.V.; Hamilton, J.H.; Wood, J.L.; Gowdy, G.M.; Fink, R.W.; Spejewski, E.H.; Schmidt-Ott, W.D.; Mlekodaj, R.L.; Carter, H.K.; Sastry, K.S.R. (Physics Department, University of Tennessee, Knoxville, Tennessee 37916). *Phys. Rev., C;* **14**: No. 4, 1586-1600(Oct 1976).

Radioactive sources containing $^{190}$Tl and $^{190}$Hg have been produced and mass separated with the University Isotope Separator on line to the Oak Ridge isochronous cyclotron. Multiscaled spectra of γ rays, x rays, conversion electrons, and positrons were obtained, and γ—γ and γ—x-ray coincidences were measured. Two isomers in $^{190}$Tl decay have half-lives of 2.6 +- 0.3 min ($2^-$) and 3.7 +- 0.3 min ($7^+$). From β decay endpoint energies the $7^+$ and $2^-$ isomers lie within 0.1 MeV of each other, but which is the ground state was not determined. Both isomers have ground-state Q/sub EC/ values of approximately 7 MeV. The $2^-$ level undergoes β decay primarily to the $2^+$ states at 416.4 and 1099.9 keV in $^{190}$Hg, while the decay of the $7^+$ isomer feeds a number of different states with spins ranging from 5 to 9. We observed the $5^-$, $7^-$, and $9^-$ members of the previously identified structure of negative-parity states resulting from coupling of a rotation-aligned $i_{13/2}$ neutron with $3p_{3/2}$ and $2f_{3/2}$ neutrons. Some additional states having decays consistent with ($6^-$) and ($8^-$) assignments perhaps are candidates for less aligned members of the 13/2$^+$ band coupled with $p_{3/2}$ and $f_{5/2}$ neutrons. The 20-min $^{190}$Hg isotope decays approximately 65% of the time to a level at 171.5 keV, thus making it difficult to study other levels in $^{190}$Au. Four new states in $^{190}$Au were definitely established, while several new ones were suggested by the present work. The populated levels are predominantly low spin and are fairly closely spaced. The log-ft value for the transition to the 171.5-keV level is 5.7, so it is likely that this state has a spin and parity of $1^+$. (AIP)

### ENERGY LEVELS AND TRANSITIONS

*REFER ALSO TO CITATION(S) 6078, 6082*

### NUCLEAR REACTIONS AND SCATTERING

*REFER ALSO TO CITATION(S) 6086*

**6079** (RLO—1388-307) **Analyzing power for proton—elastic scattering from $^{208}$Pb near the low-lying isobaric analog resonances.** Baker, M.P.; Blair, J.S.; Cramer, J.G.; Preikschat, E.; Weitkamp, W. (Washington Univ., Seattle (USA)). 1975. Contract E(45-1)-1388. 2p. (CONF-750829—12). Dep. NTIS $3.50.

From 4. international symposium on polarization phenomena in nuclear reactions; Zurich, Switzerland (25 Aug 1975).

Analyzing power (A) and differential cross section (sigma) excitation functions have been simultaneously measured for elastic proton scattering from $^{208}$Pb over the energy range 14—18 MeV in which the low-lying IAR are observed. Left-right asymmetries produced by the polarized proton beam scattering from an isotopic $^{208}$Pb target were measured at scattering angles of 135, 150, and 165° using Si(Li) detectors with acceptance angles of +-2°. The disagreement in the literature over the values of the elastic partial widths for low-lying IAR has been resolved.

**6080** (RLO—1388-309) **Analyzing power in the $^{208}$Pb(p vector,$p_0$)$^{208}$Pb reaction near the 3p/sub 1/2/ isobaric analog resonance.** Baker, M.P.; Trainor, T.A.; Blair, J.S.; Cramer, J.G.; Weitkamp, W.G. (Washington Univ., Seattle (USA)). 1975. Contract E(45-1)-1388. 2p. (CONF-750829—9). Dep. NTIS $3.50.

From 4. international symposium on polarization phenomena in nuclear reactions; Zurich, Switzerland (25 Aug 1975).

Excitation functions have been obtained for the $^{208}$Pb(p(pol),p) reaction in the vicinity of the $3p^1/_2$ IAR at 120, 150, and 165 degrees for proton energies of 11-13.6 MeV. This enables accurate determination of the elastic partial width and resonance mixing phase. (SDF)

**6081** **Experiments on the synthesis of element 107.** Oganesyan, Y.T.; Demin, A.G.; Danilov, N.A.; Ivanov, M.P.; Il'inov, A.S.; Kolesnikov, N.N.; Markov, B.N.; Plotko, V.M.; Tret'yakova, S.P.; Flerov, G.N. (Joint Institute for Nuclear Research). *JETP Lett. (USSR) (Engl. Transl.);* **23**: No. 5, 277-279(5 Mar 1976).

Results are presented of experiments on the synthesis of the 107th element. Bombardment of $^{209}$Bi by $^{54}$Cr has revealed new spontaneously fissioning emitters with half-lives ~5 sec and ~2 msec. Different control experiments using the crossing-reaction method give grounds for assuming that activity with $T_1/_2$ ~5 sec is due to the spontaneous fission of the isotope $^{257}$105, which is formed as a result of the α decay of the isotope $^{261}$107, which has a half-life of about 2 msec in a noticeable fraction of the events (~20%) and experiencing spontaenous fission. (AIP)

**6082** **Resonance neutron capture by $^{209}$Bi.** Macklin, R.; Halperin, J. (Oak Ridge National Laboratory, Oak Ridge, Tennessee 37836). *Phys. Rev., C;* **14**: No. 4, 1389-1391(Oct 1976).

Neutron capture measurements were made for bismuth samples up to the inelastic scattering threshold at 901 keV (lab). All resonance peaks (l = 0, 1) between 2.6 and 30 keV were fitted to single level parameters by least squares adjustment. From 30 to 70 keV the resonances reported from recent neutron transmission studies were fitted. Average radiative widths found were (164 +- 45) meV for l = 0 and (33.7 +- 3) meV for l > or = 1. The average spacing of l > 0 levels was 1.14 +- 0.25 keV for the energy interval 2.6 to 30 keV. The astrophysical average capture (10.7 mb at kT = 30 keV) is little different from earlier estimates, but the rate of change with stellar temperature is slower. (AIP)

**6083** **Measurements and analysis of the $^{208}$Pb($^{12}$C, $^{13}$C), ($^{12}$C, $^{11}$B), and ($^{12}$C, $^{14}$C) reactions.** Toth, K.S.; Ford, J.L.C. Jr.; Satchler, G.R.; Gross, E.E.; Hensley, D.C.; Thornton, S.T.; Schweizer, T.C. (Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830). *Phys. Rev., C;* **14**: No. 4, 1471-1483(Oct 1976).

A $^{208}$Pb target was bombarded with 97.9-MeV $^{12}$C ions accelerated in the Oak Ridge isochronous cyclotron, and the reaction products were detected with a 60-cm long position-sensitive proportional counter placed at the focal plane of an Elbek spectro-

graph. Differential cross sections were measured for the $^{208}Pb(^{12}C, ^{11}B)$, $^{208}Pb(^{12}C, ^{13}C)$, and $^{208}Pb(^{12}C, ^{14}C)$ reactions. The single-nucleon transfer data, together with previous measurements taken for the same two reactions at 77.4 and 116.4 MeV, were analyzed using exact finite-range, full-recoil, distorted-wave Born-approximation calculations. Elastic scattering for $^{11}B + ^{209}Bi$ at 74.6 MeV and $^{13}C + ^{207}Pb$ at 86.1 MeV was also measured, and optical potential fits were obtained to provide potentials for use in the distorted-wave Born-approximation calculations. Both Woods—Saxon and folded potentials were used in fitting the elastic data. The importance of the various interaction terms in the distorted-wave Born approximation was studied. Good agreement was found between theory and experiment for the ($^{12}C, ^{13}C$) reactions, and the spectroscopic factors deduced were satisfactory. The data for the ($^{12}C, ^{11}B$) reactions, although also yielding satisfactory spectroscopic factors, tend to peak at smaller angles than the predicted curves. This discrepancy increases as the Q value becomes more negative or the bombarding energy is reduced, that is, as the mismatch increases between the grazing angular momenta in the entrance and exit channels. (AIP)

## NUCLEAR PROPERTIES AND REACTIONS, A=220 AND ABOVE, THEORETICAL

**6084** **Primordial superheavy element 126.** Wong, C.Y. (Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830). *Phys. Rev. Lett.*; **37**: No. 11, 664-666(13 Sep 1976).

Based on the shell corrections obtained from an extrapolated potential, the superheavy nucleus 126 in a spherical configuration does not appear to have a half-life as long as the age of the universe. Hartree-Fock calculations with Skyrme interactions do not reveal extra stability for element 126 (A=354). There is thus the possibility that the primordial superheavy element 126 observed by Gentry et al. may not be spherical. The distinction between spherical and toroidal shapes can be made by measuring the mass number of the observed superheavy element. (AIP)

### MASS, ABUNDANCE, AND BINDING ENERGY

*REFER ALSO TO CITATION(S) 6092*

## NUCLEAR PROPERTIES AND REACTIONS, A=220 AND ABOVE, EXPERIMENTAL

*REFER ALSO TO CITATION(S) 6081*

### NUCLEAR REACTIONS AND SCATTERING

**6085** **Final-state interactions in the production of hydrogen and helium isotopes by relativistic heavy ions on uranium.** Gutbrod, H.H.; Sandoval, A.; Johansen, P.J.; Poskanzer, A.M.; Gosset, J.; Meyer, W.G.; Westfall, G.D.; Stock, R. (Gesellschaft fur Shcwerionenforschung, Darmstadt, Germany). *Phys. Rev. Lett.*; **37**: No. 11, 667-670(13 Sep 1976).

Double-differential cross sections have been measured for high-energy p, d, t, $^3$He, and $^4$He particles emitted from uranium targets irradiated with $^{20}$Ne ions at energies of 250, 400, and 2100 MeV/nucleon and $^4$He ions at 400 MeV/nucleon. By using the shape and yield of the proton energy spectra, the shape and yield of the d, t, $^3$He, and $^4$He energy spectra can be deduced at all measured angles for all incident projectile energies by assuming that they are formed by a coalescence of cascade nucleons, using a model analogous to that of Butler and Pearson, and Schwarzschild and Zupancic. (AIP)

**6086** **Search for ultradense nuclei in relativistic collisions of Ar on Ca, U, and Pb.** Frankel, K.; Stevenson, J. (Department of Physics, University of California, Berkeley, California 94720). *Phys. Rev., C;* **14**: No. 4, 1455-1457(Oct 1976).

We have placed upper limits of ~ 100 nb on the production cross section of long-lived ($\tau_{1/2}$ greater than about $10^{-9}$ sec) nuclei with Z > or approx. = 26 and energy E > or approx. = 10 MeV/nucleon in interactions of 100- and 450-MeV/nucleon $^{40}$Ar ions with U and Ca targets. (AIP)

### SPONTANEOUS AND INDUCED FISSION

**6087** (ORNL/TM—5530) **Nuclear fuel cycle and actinide wastes: cross section needs and recent measurements.** Dabbs, J.W.T. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 30p. (CONF-760431—4). Dep. NTIS $4.00.

From Spring meeting of the American Physical Society; Washington, District of Columbia, United States of America (USA) (26 Apr 1976).

What happens to actinides in reactors. The growth and decay of these nuclides are controlled primarily by capture and fission cross sections and by the reactor flux, all of which are strong functions of neutron energy. A number of selected cross section measurements are still required to predict with confidence answers to two important future questions. These are (1) whether specific neutron shielding will be required during fuel transportation or reprocessing (i.e., the spontaneous fission yields expected) and (2) whether it is possible and desirable to recycle chemically separated heavy actinides in reactors and "burn" them to short-lived fission products. Recent progress in the understanding of these questions is reviewed. Several recent measurements at ORELA which are germane to these questions are described briefly. Among these are fission cross section measurements on small ultrapure samples which are intensely alpha-radioactive. An ionization chamber with hemispherical plates is used to reduce the alpha pulses counted by a factor greater than $10^{10}$ while permitting greater than 95 percent fission counting efficiency. Preliminary results of measurements on $^{245}$Cm and $^{243}$Cm and results of an earlier measurement on $^{249}$Cf with solid state detectors are presented.

**6088** **Production of Sc nuclides in the interaction of $^{238}$U with 1—300 GeV protons.** Scheidemann, O.; Porile, N.T. (Department of Chemistry, Purdue University, Lafayette, Indiana 47907). *Phys. Rev., C;* **14**: No. 4, 1534-1544(Oct 1976).

Cross sections and thick-target recoil properties of several Sc nuclides formed in the interaction of $^{238}$U with 1 to 300 GeV protons have been determined. The ranges of all the products decrease markedly between 1 and 10 GeV and only slightly thereafter. The forward-to-backward emission ratios peak at 3 GeV and decrease to a value of unity at 300 GeV. The excitation functions increase sharply up to ~ 10 GeV and go through a very shallow peak at this energy. The results are analyzed within the context of the two-step model of high-energy reactions and found to require a larger ratio of transverse to forward momentum transfer than expected on this basis. The systematics of fragment momenta are developed. (AIP)

**6089** **Evidence for sideward emission of Sc fragments in the interaction of $^{238}$U with 400 GeV protons.** Fortney, D.R.; Porile, N.T. (Department of Chemistry, Purdue University, Lafayette, Indiana 47907). *Phys. Rev., C;* **14**: No. 4, 1652-1654(Oct 1976).

Thick-target recoil properties of Sc fragments produced in the interaction of $^{238}$U with 400 GeV protons have been determined. The anisotropy parameter b/a was obtained from measurements on targets oriented either parallel or perpendicular to the proton beam on the assumption that the angular distribution of the fragments in the moving system has the form $a + b\cos^2\theta$. The weighted average value of b/a for four Sc nuclides is -0.67 +- 0.12, this value indicating that the angular distribution must show strong sideways peaking. (AIP)

## NUCLEAR THEORY

### NUCLEAR MATTER

**6090** **Dynamics of nuclear fluid. I. Foundation.** Wong, C.Y.; Maruhn, J.A.; Welton, T.A. (Oak Ridge National Lab., Tenn. (USA)). *Nucl. Phys., A;* **253**: No. 2, 469-489(24 Nov 1975).

On the basis of the time-dependent Hartree—Fock (TDHF) formulation of the many-body problem, the equation is cast into a set of conservation laws of classical type. Besides the equation of continuity, TDHF leads to an equation of motion which is analogous to the Euler equation in classical fluid dynamics. The forces do not come from the collective kinetic stress alone, but also from a density-dependent chemical potential, the surface tension force which depends on density differences, and the Coulomb interaction. With an assumed Navier—Stokes generalization of the stress tensor, such a set of differential equations provides a powerful tool for the study of complicated collective motions of nuclear systems such as those involved in heavy-ion reactions and nuclear fission. In the static case, the equation of motion leads to the Thomas—Fermi model of a finite nucleus as formulated by Bethe.

### NUCLEAR REACTIONS AND SCATTERING

*REFER ALSO TO CITATION(S) 6090*

**6091** **A nuclear analog of the Cerenkov effect.** Rumyantsev, B.A.; Telitsyn, V.B.; Yurchenko, V.I. (Nuclear Research Institute, Siberian Division, USSR Academy of Sciences). *JETP Lett. (USSR) (Engl. Transl.);* **23**: No. 5, 279-282(5 Mar 1976).

We estimate the angular and energy distributions, as well as the total probability of "spilling" of particles out of the nucleus by a shock wave generated in Cerenkov fashion in collisions of high-energy heavy ions. (AIP)

### NUCLEAR MODELS

*REFER ALSO TO CITATION(S) 6048, 6090*

**6092 Self-consistent K-matrix-model calculation for finite and superheavy nuclei.** Cusson, R.Y.; Trivedi, H.P.; Meldner, H.W.; Weiss, M.W.; Wright, R.E. (Department of Physics, Duke University, Durham, North Carolina 27706). *Phys. Rev., C;* **14**: No. 4, 1615-1629(Oct 1976).

A model two-body K matrix is introduced which leads to simple Brueckner—Hartree—Fock equations similar to those resulting from Skyrme forces. The main features of the present model are determined by basic nuclear matter properties. Experimental nucleon removal energies for finite closed-shell nuclei are used as a criterion for setting the single-particle energy levels in our model. This is accomplished by parametrizing the Brueckner rearrangement potential which augments the single-particle potential; single-particle level densities in better agreement with experiment than Skyrme-potential models or density matrix expansion theories are thereby produced. Good fits are also obtained to total binding energies, rms radii, and electron scattering form factors of the magic nuclei $^{16}O$, $^{40}Ca$, $^{90}Zr$, $^{208}Pb$. Extrapolated results for the magic superheavy nucleus $^{298}114$ are presented and discussed. (AIP)

## RADIATION AND SHIELDING PHYSICS

### RADIATION PHYSICS

*REFER ALSO TO CITATION(S) 5841, 5842*

**6093 Secondary electron spectra.** Kim, Y.K. (Argonne National Lab., IL). pp 219-226 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

A theoretical method is reported that checks the consistency of secondary-electron spectra and enables extrapolation and interpolation of the secondary-electron spectra to various regions of incident-particle and secondary-electron energies in gaseous media. The method utilizes the relationship between the oscillator-strength distribution and the Born cross sections for charged- particle impact as well as the fact that the Rutherford and Mott cross sections become valid for secondary electrons with kinetic energies far in excess of their binding energies. 4 figs, 23 refs (GHT)

**6094 Calculation of transient thermal imbalance within crystal units following exposure to pulse irradiation.** Hartman, E.F.; King, J.C. (Sandia Labs., Albuquerque, N.Mex. (USA)). *Radiat. Eff.;* **26**: No. 4, 219-223(Nov 1975).

A study has been made of temperature rises in quartz resonators using a combined photon-electron Monte Carlo transport code. This code was used to compute the energy deposited in resonator materials by pulsed (70 nanoseconds) 10 Me V Bremsstrahlung x-rays and 30 MeV electrons in geometries which model 5 MHz and 125 MHz 5th overtone quarz resonators. In general for the radiation sources considered, and for resonators operating near their frequency vs. temperature turnover point, calculations indicate that thermal shock is a significant factor in causing transient frequency shifts. Frequency shifts in MHz resonators of tenths of parts per million lasting fractions of a second are calculated for resonators exposed to a radiation pulse of $10^3$ rad.

**6095 Cross section for elastic stopping of ions as a function of the atomic number of the target atom.** Burlankov, D.E.; Volod'ko, V.G.; Zorin, E.I.; Pavlov, P.V.; Tetel'baum, D.I. (Gor'kii Research Physicotechnical Institute). *Sov. Phys. - Tech. Phys. (Engl. Transl.);* **21**: No. 3, 364-366(Mar 1976).

Hartree-Fock wave functions are used to calculate the cross sections for the elastic stopping of ions. The results are compared to those obtained from using the Thomas-Fermi potential. Boron ions at an energy of iokev and phosphorous ions at an energy of Sukev are considered. (AIP)

**6096 Energy-loss distributions of fission fragments.** Demidovich, N.N.; Nakhutin, I.E.; Shatunov, V.G. *JETP Lett. (USSR) (Engl. Transl.);* **23**: No. 5, 266-269(5 Mar 1976).

The f-f coincidence method was used to investigate the change in the form of the energy-loss distributions of $Cf^{252}$ fission fragments. in air, down to fragment energies ~0.8 MeV. A theoretical model is considered for the estimate of the mean-squared deviations of the fragment energy-loss distributions. (AIP)

**6097 Theory of ion range in amorphous targets.** Ledovskoi, V.P.; Mamaev, G.I. (V. I. Ul'Yanov (Lenin) Electrical Engineering Institute, Leningrad). *Sov. Phys. - Solid State (Engl. Transl.);* **18**: No. 6, 747-749(May 1976).

Refinements are made to the Lindhard-Scharff-Schiott theory, which applies to the penetration of heavy ions ($\mu=M_2/M_1$very-much-less-than1) whose dimensionless energy is $\epsilon>$ or =0.02. It is shown that in practice the initial energy can be $\epsilon$very-much-less-than0.02 if $z_1>35$ (and if the energy is several kilo-electron-volts, this applies also to low values of $z_1$). A method is developed in which allowance is made for the probability of large-angle scattering, the exact expression is used for the scattering of ions in the laboratory system, collisions with large impact parameters are included by introducing a screening function proposed by Nikulin, and so on. All these refinements make it possible to estimate the projection of the range of ions of any mass with energies down to $\epsilon=10^{-4}$. The approximate expression for the electron retardation can be used to carry out calculations as a function of $\epsilon$ and $\mu$ alone. All the calculations are made in terms of dimensionless parameters and this simplifies the analysis. The refined theory is in good agreement with the experimental results. (AIP)

### NEUTRON INTERACTIONS WITH MATTER

*REFER ALSO TO CITATION(S) 4985, 4986, 5098, 5792, 5965, 6063*

**6098 Quasielastic scattering of neutrons in water.** Gordeev, G.P.; Khaidarov, T. (B. P. Konstantinov Institute of Nuclear Physics, USSR Academy of Sciences). *JETP Lett. (USSR) (Engl. Transl.);* **23**: No. 4, 13-17(20 Feb 1976).

The spectrum of quasielastic neutrons in water has a complicated structure, due to rotations of the molecules. At momentum transfers $k<2$ $A^{-1}$, this spectrum is satisfactorily described by two components. It then becomes possible to extract information on the microdynamics and structure of water. (AIP)

**6099 Spectra and dose measurements in liquid air for neutrons from a $^{252}Cf$ sourse.** Buchholz, F.W. (Wehrwissenschaftliche Dienststelle der Bundeswehr fuer ABC Schutz, Munster, Ger.); Schaenzler, L.; Stueker, S.; Tumbraegel, G.; Weinert, M.; Clausen, K.; Schneider-Kuehnle, P. *Trans. Am. Nucl. Soc.;* **23**: 613-614(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6100 Comparison of P1 synthetic acceleration techniques.** Lewis, E.E. (Northwestern Univ., Evanston, IL); Miller, W.F. Jr. *Trans. Am. Nucl. Soc.;* **23**: 202-203(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6101 Stable diffusion synthetic acceleration method for neutron transport iterations.** Alcouffe, R.E. (Los Alamos Scientific Lab., NM). *Trans. Am. Nucl. Soc.;* **23**: 203(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6102 Theoretical analysis of coarse-mesh accelerating effect.** Nakamura, S. (Ohio State Univ., Columbus). *Trans. Am. Nucl. Soc.;* **23**: 205(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6103 Alternating direction checkerboard methods.** Hendricks, J.S. (Los Alamos Scientific Lab., NM); Henry, A.F. *Trans. Am. Nucl. Soc.;* **23**: 206-207(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6104 Complex combinatorial geometry.** Steinberg, H. (MAGI, Elmsford, NY). *Trans. Am. Nucl. Soc.;* **23**: 207-208(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## MEDICAL PHYSICS

**6105 Associate and baccalaureate degree program in radiation technology.** Johnson, H.M.; McNeil, P.R. (Oklahoma State Univ., Stilwater). *Trans. Am. Nucl. Soc.*; **23**: 82(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

### RADIATION PROTECTION STANDARDS

*REFER ALSO TO CITATION(S) 5676*

### RADIATION SOURCE CALIBRATION AND STANDARDIZATION

**6106 Irradiation damage flux characteristics in DIDO type reactors.** Genthon, J.P.; Kelly, B.T.; Wright, S.B. (CEA, Saclay, France). *Nucl. Instrum. Methods;* **131**: No. 1, 1-12(1 Dec 1975).

In the GAMIN technique an index r, the rate of graphite damage divided by the rate of nickel activation, is determined by the use of a French graphite standard. Two series of r determinations have been carried out in the DIDO reactor together with a comparison between GAMIN and a U.K. graphite standard, PGA KD/RE, irradiated together in the ISIS reactor. It is found that GAMIN measurements and calibrated PGA measurements give the same results. Comparison of calculations and DIDO measurements confirm the GAMIN calibration established in other reactors, and in OSIRIS in particular. The relative values of r are compared for various light water, heavy water, graphite and fast reactors. 10 refs.

### DOSIMETRY

*REFER ALSO TO CITATION(S) 6099*

## SOLID STATE PHYSICS

*REFER ALSO TO CITATION(S) 5966, 6132*

**6107** (CONF-760421—8) **Dispersion strengthening.** Scattergood, R.O.; Das, E.S.P. (Argonne National Lab., Ill. (USA)). 1976. Contract W-31-109-Eng-38. 13p. Dep. NTIS $3.50.

From Conference on computer simulation for materials applications; Gaithersburg, Maryland, United States of America (USA) (19 Apr 1976).

Using digital computer-based methods, models for dispersion strengthening can now be developed which take into account many of the important effects that have been neglected in the past. In particular, the self interaction of a dislocation can be treated, and a computer simulation method to determine the flow stress of a random distribution of circular, impenetrable obstacles has been developed taking into account all such interactions. The flow stress values depend on the obstacle sizes and spacings, over and above the usual 1/L dependence, where L is the average obstacle spacing. From an analysis of the results, it was found that the main effects of the self-interactions can be captured in a line tension analog in which the obstacles appear to be penetrable.

**6108** (CONF-760421—9) **Computer simulation of the chemical potential.** Murch, G.E.; Thorn, R.J. (Argonne National Lab., Ill. (USA)). 1976. Contract W-31-109-Eng-38. 8p. Dep. NTIS $3.50.

From Conference on computer simulation for materials applications; Gaithersburg, Maryland, United States of America (USA) (19 Apr 1976).

In the past, Monte Carlo simulation in the petite canonical ensemble has been seriously hampered by the inability to calculate thermodynamic quantities in the form of direct averages. Recently, Baker has advanced a timely method for calculating the chemical potential in the two dimensional physical adsorption problem. The method is based on the realization that the chemical potential is simply related to the energy required to introduce a new particle into the ensemble, as suggested much earlier by Widom. The method is generalized here in the form of the f.c.c. lattice gas and reformulated in terms of the energy required to remove a particle from the ensemble. This energy is easier to compute than in the former case since it can be easily related to the configurational energy of the ensemble. Results of calculations of the chemical potential as a function of composition and temperature are presented. Results of such calculations on the petite ensemble are compared with results on the grand ensemble.

**6109** (N—75-22103) **Electron emission currents of metals covered with atomic layers.** Wagner, S. Translated from *Wiss. Z. Univ. Rostock, Math.-Naturwiss. Reihe;* **16**: No. 7, 887-892(1967). 18p. (NASA-TT-F—16173). NTIS $3.25.

A physical model is given for the evaporation equilibrium process of atoms on electron emitters made of metal; concrete parameters are placed into its general framework. The model considered explains the experimental results in a qualitative manner; but for the quantitative interpretation of the measured curves, additional assumptions and sophistications are needed. By means of an experimental example, the importance of an adequate calculation of the average work function and emission current density is demonstrated. (auth)

**6110 Useful diagrammatic approximation scheme for ground-state and phonon calculations of solid helium.** Bolterauer, H.; Gillessen, P. (Giessen Univ. (F.R. Germany). Inst. fuer Theoretische Physik). pp 471-474 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Nearly all T-matrix theories concerning solid Helium end up with the task to solve a two-particle problem. The considered particles interact via some two-particle potential and are moving in an external potential U, which has to be determined by some selfconsistency procedure. The theories differ firstly in the resulting two-particle potential and secondly in the procedure to determine U. The phenomenological theories are reformulated in a systematic way using diagram techniques.

**6111 Desorption of $^4$He atoms by phonons.** Crisp, G.N.; Sherlock, R.A.; Wyatt, A.F.G. (Nottingham Univ. (UK)). pp 455-458 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In some recent experiments it has been shown that the reflectivity of a crystal surface, for phonons incident on it from within the crystal, is sensitive to very thin layers of helium on the crystal surface. The direct test of whether atoms can be desorbed by phonons is to repeat the reflection experiment with an additional bolometer in the vapor on the reflection side of the crystal. It is now clear that the loss in energy of phonons reflecting off a crystal-helium film interface is due to the desorption of helium atoms. It is not unlikely that the same mechanism occurs at interfaces of solids and bulk $^4$He and the excited atoms rapidly decay into phonons with a broad angular distribution.

**6112 Thermal properties of bcc $^3$He.** Franck, J.P.; Calder, I.D. (Alberta Univ., Edmonton (Canada). Dept. of Physics). pp 495-498 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The specific heat and related thermal properties of bcc $^3$He exhibit unusual behaviour for a dielectric. At low temperatures, the specific heat varies linearly with temperature, while at higher temperatures it is anomalously large. As suggested by Guyer, the symmetry of the two specific heat anomalies invites a search for a common explanation.

**6113 Elastic constants of bcc $^4$He.** Greywall, D.S. (Bell Labs., Murray Hill, N.J. (USA)). pp 483-486 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Longitudinal and transverse sound velocities have been measured in single crystals of bcc $^4$He at a molar volume of 21.00 cm$^3$. The samples were grown at nearly constant pressure in a plastic freezing cell by lowering the temperature of the copper freezing tip from just above the melting temperature to a temperature a few mK above the bccyieldshcp phase transition. Data were taken on 61 crystals. A weighted least-squares fitting of the velocity data yielded the elastic constants.

**6114 Ultrasonic attenuation of solid helium.** Hiki, Y.; Tsuruoka, K. (Tokyo Inst. of Tech. (Japan)). pp 479-482 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The present study is intended to measure the ultrasonic attenuation of solid helium which is known to have interesting lattice properties. The ultrasonic pulse echo method of reflection type has been adopted for measuring the attenuation and velocity of sound in h.c.p. $^4$He crystals.

**6115 Four-spin exchange in bcc $^3$He.** McMahan, A.K.; Wilkins, J.W. (Cornell Univ., Ithaca, N.Y. (USA). Lab. of Atomic and Solid State Physics). pp 507-508 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The results of a Monte Carlo calculation using self-consistent phonons indicates that a significant four-spin term must be added to the Heisenberg exchange Hamiltonian. The predictions of the mean-field approximation are sketched in which the exchange Hamiltonian reduces to a Heisenberg nearest-neighbor Hamiltonian with a temperature-dependent exchange frequency J(T) depending on a thermal average of the scalar product of the nearest-neighbor spins.

**6116 Short-range and long-range correlations in the ground state of a one-dimensional quantum crystal model.** Mertens, F.G. (Giessen Univ. (F.R. Germany). Inst. fuer Theoretische Physik). pp 467-470 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In general the ground state energy of a quantum crystal can be calculated only approximately, e.g. by a cluster expansion. However an exact evaluation is possible in the 1-dimensional case by the transfer integral method, if only nearest neighbour (n-n) correlations are considered. It is shown that the variation of energy with respect to the 2-particle function f for fixed 1-particle function phi leads to a Schroedinger equation which is coupled to the transfer integral equation by an effective potential. This potential describes how a nearest neighbour pair is influenced by the other particles. The optimal f can be computed by a self consistent method and describes both short and long range correlations. Numerical results are given for helium and deuterium.

**6117 Theory of three-body effects in $T_1$ for $^3$He in solid $^4$He.** Mullin, W.J. (Massachusetts Univ., Amherst (USA)). pp 517-519 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Recently Richards et al have reported $T_1$ data for dilute solutions of $^3$He in $^4$He. Their results for $T_1^{-1}$ show two distinct peaks submerged in an approximately exponential background. A theory involving the tumbling of a pair of $^3$He atoms through the lattice with direct Zeeman to lattice transfer of energy (without the intermediate exchange bath) has been constructed and described elsewhere. It is believed that this theory explains the existing data. Nevertheless, the idea that sharp spectral lines resulting from the exchange of three $^3$He atoms might be observable is tantalizing. Therefore it is of value to present a calculation of the contribution of such processes to $T_1^{-1}$ in the hopes that future experiments may permit their observation.

**6118 Model of inelastic heat-transfer mechanism for the excess Kapitza conductance.** Namaizawa, H. (Universitaet des Saarlandes, Saarbruecken (F.R. Germany). Fachrichtung Theoretische Physik). pp 459-462 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A model which leads to an excess inelastic heat transfer between a classical solid and a quantum system is proposed. Due to the strong van der Waals force from the solid, a molecule of the quantum system feels a strong anisotropic force in a direction normal to the interface when it approaches the interface. If the force is strong enough, molecules are bound along the interface to form layers. As is shown by the Juelich group, the mechanism of excess thermal conductance is hidden in the first few layers. In this work, liquid $^4$He is taken as the quantum system and Jackson's theory of $^4$He monolayer is applied to study physical behavior of the layer.

**6119 Reaction-matrix calculation of ground-state and vibrational properties of bcc $^3$He and $^4$He.** Namaizawa, H. (Universitaet des Saarlandes, Saarbruecken (F.R. Germany). Fachrichtung Theoretische Physik). pp 475-478 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

Numerical works were done to calculate ground-state and vibrational properties of bcc $^3$He and $^4$He by using an approximate S-wave correlation function. While the results are in reasonable agreement with experiment, it is desirable to recalculate those physical properties by solving the correlation function precisely. In the present work the two-body correlation function is solved in terms of partial waves including partial-wave amplitudes up to l=15.

**6120 Ballistic phonons and the transition to second sound in solid $^3$He.** Narayanamurti, V.; Dynes, R.C. (Bell Labs., Murray Hill, N.J. (USA)). pp 499-502 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

A study of heat pulse propagation in solid $^3$He as a function of temperature (between .05K and .5K) and molar volume (24.5 cm$^3$/mole to 23.7 cm$^3$/mole) is reported. The fast heat pulse technique is used and data is presented which shows the transition from ballistic flow to second sound. Evidence for unusual behavior in the temperature dependence of the velocity and intensity of the slow transverse phonon (propagating close to [110]) is presented. The implications of these measurements for specific heat data are discussed.

**6121 Spin-phonon renormalization effects in solid $^3$He.** Nosanow, L.H. (National Science Foundation, Washington, D.C. (USA)); Varma, C.M. (Bell Labs., Murray Hill, N.J. (USA)). pp 503-506 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The thermodynamical consequences of the spin-phonon coupling in a nearest neighbour Heisenberg model are studied with a view to understanding the experimental results in solid $^3$He.

**6122 Entropy of solid $^3$helium between 1 and 23 mK.** Rasmussen, F.B. (Copenhagen Univ. (Denmark). H.C. Oersted Inst.); Halperin, W.P.; Archie, C.N.; Richardson, R.C. (Cornell Univ., Ithaca, N.Y. (USA). Lab. of Atomic and Solid State Physics). pp 513-516 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The entropy of solid $^3$He has been measured on the melting curve and the specific heat derived. The results are consistent with the idea that the effective exchange interaction is temperature dependent. Evidence for such an idea has been obtained previously from experiments on spin diffusion. This temperature dependence may originate from quadrupole exchange processes.

**6123 Pressure dependence of NMR data for dilute $^3$He in solid $^4$He.** Richards, M.G.; Smith, J.H.; Tofts, P.S. (Sussex Univ., Brighton (UK). School of Mathematical and Physical Sciences). pp 520-523 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

In the last four years, groups at Cornell, Sussex and Kharkov have carried out NMR studies of $^3$He in solid $^4$He close to the melting curve. Using simple models to interpret the data, values for the $^3$He-$^4$He quantum tunnelling frequency, $J_{34}$, of $10^4$-$10^5$ sec$^{-1}$ have been deduced. These values are 2—3 orders of magnitude below $J_{33}$, the tunnelling frequency for neighbouring particles in pure solid $^3$He of similar lattice spacing. During this time, three groups of theorists have developed alternative models which lead to values of $J_{34}$ closer to that expected, i.e. closer to $J_{33}$. Reported here are new data on the spin diffusion coefficient D and the NMR relaxation times $T_1$ and $T_2$ which give direct experimental evidence that $J_{34}$ is of the order of $J_{33}$.

**6124 Ground state properties of bcc $^3$He: test of the point transformation method.** Trickey, S.B. (Florida Univ., Gainesville (USA). Dept. of Physics and Astronomy); Witriol, N.M. (Redstone Scientific Information Center, Redstone Arsenal, Ala. (USA)); Koehler, T.R. (IBM Research Labs., San Jose, Ca., USA). pp 491-494 of In Low temperature physics. Vol. I. Krusius, M.; Vuorio, M. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 14. international conference on low temperature physics; Otaniemi, Finland (14 Aug 1975).

The systematic treatment of short-range, hard-core correlations in the self-consistent lattice dynamics of a quantum crystal has been developed in terms of point transformations (PT) at the level of two-body additivity. An outline is presented of the results from a full implementation of the theory in the computer codes previously developed for the Correlated Basis Function (CBF) treatment of the same problem. Calculations on bcc $^3$He are presented.

**6125 Existence of a phase transition on a classical lattice spin system with three-spin interactions.** Suranyi, P. (Department of Physics, University of Cincinnati, Cincinnati, Ohio 45221). *Phys. Rev. Lett.*; 37: No. 12, 725-728(20 Sep 1976).

It is shown that an appropriately defined magnetization has a zero thermal average above a critical temperature and a nonzero average below it for a specific lattice Hamiltonian with three-spin interactions in two or more dimensions. This work implies the existence of a phase transition in Reggeon field theory. (AIP)

## SUPERCONDUCTIVITY

### ACOUSTIC, ELECTRIC, MAGNETIC, OPTICAL, AND THERMAL PHENOMENA

*REFER ALSO TO CITATION(S) 5319, 5352, 5353, 5358, 5362, 5363, 5409, 5410, 5411, 5440, 5500*

**6126 (ANL—76-XX-8) Photoexcitation in superconductors.** Schuller, I. (Argonne National Lab., Ill. (USA)). Jun 1976. Contract W-31-109-Eng-38. 142p. Dep. NTIS $6.00.

Thesis.

A measurement has been made for the first time of the relaxation time of the superconducting order parameter and the equilibrium energy gap close to T/sub c/. The results indicate that the relaxation time of the magnitude of the order parameter diverges as 1/Δ/sub eq/ for T/T/sub c/ greater than or equal to 0.99, in agreement with theory. The inelastic collision time for electrons determined from this experiment is consistent with surface-Landau-level-resonance experiments and theory.

**6127 Viscosity of vortices in pure superconductors.** Larkin, A.I.; Ovchinnikov, Y.N. (L. B. Landau Institute of Theoretical Physics, USSR Academy of Sciences). *JETP Lett. (USSR) (Engl. Transl.)*; 23: No. 4, 21-23(20 Feb 1976).

The vortex viscosity at low temperatures was obtained for pure superconductors with electron mean free path l satisfying the conditions $vT^{-1}<<l$, v∈/sub F/T/sub c/ $^{-3}$. Accurate to a factor ln(Δ/T), the results correspond to the assumption that there exist normal regions with dimensions on the order of $\xi_\phi$=v/T/sub c/. (AIP)

## THEORETICAL PHYSICS

### GENERAL AND MISCELLANEOUS

*REFER ALSO TO CITATION(S) 5155*

**6128 Possibility of observing local anisotropy of space-time with the aid of the Doppler effect.** Bogoslovskii, G.Y. (Nuclear Physics Institute of Moscow State University). *JETP Lett. (USSR) (Engl. Transl.)*; 23: No. 4, 4-5(20 Feb 1976).

A relativistic expression is obtained for the Doppler effect in a locally anisotropic space. The effect is sensitive to the orientation of the experimental setup in space. It is proposed to set up a corresponding experiment for the purpose of observing local anisotropy of space. (AIP)

### CLASSICAL AND QUANTUM MECHANICS

*REFER ALSO TO CITATION(S) 5310*

**6129 Toward a fundamental mechanics. III.** Phipps, T.E. Jr. (Naval Surface Weapons Center, White Oak, MD). *Found. Phys.*; 6: No. 3, 263-273(Jun 1976).

The possibility was examined of accomplishing the entirety of physical description by means of mechanics, without help from field-theoretical ideas. Apart from some easily obtained qualitative agreements with general descriptive features of nuclei and elementary particles, one was balked in this program by an inability to handle in purely mechanical terms the relativistic many-body problem. The latter problem is considered. No quantitative calculations are attempted, but three suggestions are made—each of a quite radical nature—concerning the reformulation that will be necessary to restore mechanics to the mainstream of physics.

**6130 New four-dimensional symmetry.** Hsu, J.P. (National Research Council of Canada, Ottawa). *Found. Phys.*; 6: No. 3, 317-339(Jun 1976).

A new picture of nature is proposed in which there are only two fundamental universal constants anti e (identical with e/c) and dirac constant (identical with dirac constant/c). The theory is developed within the framework of a new four-dimensional symmetry which is constructed on the basis of the Poincare—Einstein principle of relativity for the laws of physics and the Newtonian concept of time. One obtains a new space—light transformation law, a velocity-addition law, and so on. In this symmetry scheme, the speed of light is constant and is completely relative. The new theory is logically self-consistent, and it moreover is in agreement with all previously established experimental facts, such as the "lifetime dilatation" of unstable particles, the Michelson—Morley experiment, etc. There is a difference relative to the usual theory, though, in that our theory predicts a new law for the Doppler frequency shift, which can be tested experimentally by measuring the second-order frequency shift.

**6131 Why "a watched pot never boils".** Wolsky, A.M. (Argonne National Lab., IL). *Found. Phys.*; 6: No. 3, 367-369(Jun 1976).

It is shown that as a system which can be characterized by a finite-dimensional Hilbert space is observed more and more frequently, the probability that it will always be found in its initial state tends to one.

### STATISTICAL PHYSICS AND THERMODYNAMICS

*REFER ALSO TO CITATION(S) 6108*

**6132 New method for obtaining exact solutions of the Ising problem for finite arrays of coupled chains.** Fedro, A.J. (Northern Illinois University, DeKalb, Illinois 60115). *Phys. Rev., B*; 14: No. 7, 2983-2988(1 Oct 1976).

A new exact method for calculating thermodynamic averages and multisite correlation functions for an arbitrary array of infinite linear chains interacting via the Ising Hamiltonian in a magnetic field is presented. The general analytical properties of such solutions for planar arrays have been discussed by Kramers and Wannier and by Ferdinand and Fisher, although no formal expressions could be given. The limit of an infinite planar array of chains, of course, was solved by Onsager. As shown by Ferdinand and Fisher the three-chain problem already has a specific-heat behavior remarkably similar to that of the Onsager case apart from the integrable singularity and serves as a good approximation to the infinite planar array. (AIP)

### ELECTRICITY AND MAGNETISM

**6133 (UCRL—77974) Moment-method techniques in electromagnetics from an application's viewpoint.** Miller, E.K.; Poggio, A.J. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 11 Jun 1976. Contract W-7405-eng-48. 61p. (CONF-760610—2). Dep. NTIS $4.50.

From National conference on electromagnetic scattering theory; Chicago, Illinois, United States of America (USA) (15 Jun 1976).

The various issues of concern in the practical application of Moment—Method techniques in electromagnetics are discussed. Special attention is devoted to the steps involved in the development and use of a computer model. A survey of the state-of-the-art in connection with problem types most often encountered is also given. A recommendation is made for a methodological framework to be developed for EM problem solving to more effectively exploit analytical, computational and experimental procedures.

## MATHEMATICAL PHYSICS

*REFER ALSO TO CITATION(S) 6414*

# CONTROLLED THERMONUCLEAR RESEARCH

*REFER ALSO TO CITATION(S) 4612, 4613, 5505*

**6134 (MATT—1(Suppl.5)) Bibliography of Plasma Physics Laboratory publications and reports covering period January 1—December 31, 1975.** (Princeton Univ., N.J. (USA). Plasma Physics Lab.). Jul 1976. Contract E(11-1)-2073. 9p. Dep. NTIS $3.50.

This listing includes 98 references to reports issued by the Plasma Physics Laboratory during the period January through December 1975. (MOW)

**6135 Plasma physics index. Volume 11, No. 7, 1976. Bibliography, author index, subject index.** Leopoldshafen, Ger.; Zentralstelle fuer Atomkernenergie-Dokumentation (1976). 134p.

**6136 Technology index for plasmaphysics research and fusion reactors. Volume 10, No. 7, 1976. Bibliography, author index, subject index, appendix.** Leopoldshafen, Ger.; Zentralstelle fuer Atomkernenergie-Dokumentation (1976). 48p.

**6137 Preheat by fast electrons in laser-fusion experiments.** Yaakobi, B.; Pelah, I.; Hoose, J. (Laboratory for Laser Energetics, University of Rochester, Rochester, New York 14627). *Phys. Rev. Lett.*; 37: No. 13, 836-839(27 Sep 1976).

Neon-filled glass spherical shell targets were irradiated by a four-beam laser system of incident power 0.6—0.8 TW. By measuring Kα x-ray lines of neon and silicon we are able to determine the number of fast (nonthermal) electrons and their preheating effect. Correlation is made with fast ion measurements. (AIP)

## PLASMA RESEARCH

*REFER ALSO TO CITATION(S) 5601, 5630*

**6138 Plasma-optical transformation of a quasisteady plasma stream.** Demidenko, I.I.; Lomino, N.S.; Padalka, V.G. (Physicotechnical Institute, Academy of Sciences of the Ukrainian SSR, Khar'kov). *Sov. Phys. - Tech. Phys. (Engl. Transl.)*; 21: No. 3, 284-288(Mar 1976).

In an analysis of the possible use of an axisymmetric plasma lens to transform the properties of the plasma stream produced by a Hall-current accelerator with a long acceleration zone it is shown that such a plasma-optical system effectively focuses a high-current, neutalized ion beam. (AIP)

### PLASMA CONFINEMENT AND HEATING

*REFER ALSO TO CITATION(S) 6165, 6167, 6222, 6242, 6373*

**6139** (CONF-761012—4) **Confinement and neutral beam injection studies on ORMAK (Draft).** (Oak Ridge National Lab., Tenn. (USA)). 25 Aug 1976. Contract W-7405-eng-26. 35p. Dep. NTIS $4.00.

From 6. international conference on plasma physics and controlled nuclear fusion research; Berchtesgaden, German, Federal Republic of (F.R. Germany) (6 Oct 1976).

Plasma confinement and neutral beam injection heating were investigated on the Oak Ridge Tokamak (ORMAK) plasma with improved plasma parameters due to higher injection power (to 360 kW), discharge current (to 220 kA) and toroidal field (to 26 kG). With increasing injection power up to 360 kW with otherwise constant operational parameters, the central ion temperature increased roughly linearly from 0.7 keV to 1.8 keV. The scaling of ion temperature with injection power and plasma density reasonably agrees with theoretical predictions based on neoclassical ion heat conduction and classical beam energy transport.

**6140** (COO—2277-8) **High beta capture and mirror confinement of laser produced plasmas. Semiannual report, February 1, 1976—June 30, 1976.** Haught, A.F.; Polk, D.H.; Fader, W.J. (United Technologies Research Center, East Hartford, Conn. (USA)). Jun 1976. Contract E(11-1)-2277. 96p. Dep. NTIS $5.00.

Separate abstracts were prepared for the 4 included sections. (MOW)

**6141** (COO—2277-8, pp 28p, Paper I) **Magnetic confinement of laser produced LiH plasma in LITE.** Ard, W.B.; Stufflebeam, J.H.; Tomlinson, R.G. Jun 1976.

In High beta capture and mirror confinement of laser produced plasmas.

In the LITE experiment, a hot, dense plasma produced by laser heating of an approximately 100 μ dia LiH particle is used to fill a minimum-B baseball coil mirror magnetic containment field. The confined laser produced plasma subsequently serves as the target for an energetic neutral hydrogen beam in experiments to investigate the target plasma buildup approach for creating and sustaining an equilibrium, steady state mirror fusion plasma. In the experiments, the LiH particle is positioned in vacuum at the laser beam focus by a feedback particle suspension system and heated by two sided irradiation with the focused dual beam, 50 j, 7 nsec output of a Q-switched Nd-glass laser. The energy density of the laser produced plasma is initially much greater than that of the surrounding magnetic field and the plasma expands, converting its internal energy into expansion kinetic energy and displacement of the magnetic field. As the energy density falls below that of the magnetic field, the expansion is stopped and the plasma becomes trapped, making the transition to a low beta, mirror confined plasma. This report is concerned with the properties and behavior of the plasma in the confinement stage.

**6142** (COO—2277-8, pp 30p, Paper II) **Hot ion buildup by low current neutron beam injection in LITE.** Tomlinson, R.G.; Ard, W.B.; Fader, W.J.; Polk, D.H.; Mensing, A.E.; Stufflebeam, J.H. Jun 1976.

In High beta capture and mirror confinement of laser produced plasmas.

The laser produced target plasma confined in the LITE minimum-B mirror magnetic field is shown along with a drawing of the confinement field line configuration. The plasma is generated by two beam, 1.06 micron, Nd-glass laser irradiation of LiH particles approximately 100 microns in diameter producing a plasma of approximately $10^{16}$ hydrogen and lithium ions which expands in and is captured by the "baseball" confinement field. The plasma luminosity displays a plasma configuration which corresponds to the magnetic field geometry and indicates a plasma volume of approximately 400 $cm^3$. Probe and microwave measurements confirm the plasma distribution indicated by the luminosity photographs. Charge collector probes located at a series of positions over a 120° arc in the mirror fan permit simultaneous observations of the plasma decay along field lines which pass through the mid-plane at different radial distances from the magnetic field axis. Plasma flux is observed with these probes to field lines 6 cm from the axis. Microwave measurements have been made with a strongly focused, 75 GHz (lambda = 4 mm) beam passing through the mid-plane, orthogonal to the mirror axis. Cut-off of the microwave beam transmission early in the confined plasma time history indicates that the radial dimension of the high density plasma region exceeds 2 cm. Measurement of the line density via interferometric measurements of the phase shift of the transmitted beam when the density has fallen below cut-off indicates an "effective" diameter of approximately 5 cm and an axial extent of approximately 20 cm. Thus, the plasma presents approximately 100 $cm^2$ target area to an incident neutral beam and occupies approximately 400 $cm^3$ volume.

**6143** (COO—2277-8, pp 21p, Paper IV) **LITE neutral beam line upgrade.** Churchill, T.L.; Mensing, A.E. Jun 1976.

In High beta capture and mirror confinement of laser produced plasmas.

The neutral beam line on the Laser Initiated Target Experiment (LITE) is being upgraded to increase the injection capability by a factor of 50. Described herein are the ion source and power conditioning necessary to achieve this goal. Also described are the anticipated performance figures of the new beam line including the impact of the increased gas load on the system vacuum levels.

**6144** (ERDA—76/115) **Report of the Ad Hoc Panel on rf heating in tokamaks.** (Energy Research and Development Administration, Washington, D.C. (USA)). Jul 1976. 160p. Dep. NTIS $6.75.

The panel evaluated the theoretical basis for both neutral beam and rf heating techniques. It considered whether the theory had been substantiated by experimental data. It also addressed critical technological problems that had already been identified or that might be expected to appear in future experiments.

**6145** (UCID—17244) **End stoppering in mirror machines.** Fowler, T.K. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 24 Aug 1976. Contract W-7405-Eng-48. 17p. Dep. NTIS $3.50.

Like toroidal confinement, confinement by a potential barrier offers the possibility of unlimited Q if the barrier is good enough. For a barrier height PHI, approximately tau approximately equal to tau/sub collision/ exp PHI/T/sub i/. These notes review previous ideas about how to establish a potential barrier at the ends of a mirror machine and we also discuss a different possibility using mirror confinement itself to establish a barrier utilizing the positive ambipolar potential characteristic of mirror machines. One example consists of three mirrors in tandem, the two at the ends having a much smaller volume. Then mirror confinement in the end cells would be used to establish ambipolar barriers that stopper up the ends of the central, large mirror cell. An example is discussed in which, by approximate calculation, it appears that ignition might occur in a center cell 10 to 20 meters long and the overall Q is 5 or more, including the power required to sustain the end cells by neutral injection.

**6146 Turbulent heating of the ions by lower hybrid fields.** Baikov, I.S. (P.N. Lebedev Physical Institute, Moscow, USSR). pp 327 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The author investigates turbulent heating of the ions in a plasma embedded in a magnetic field in the presence of a high frequency external electric field at the lower hybrid frequency which can excite decaying and growing parametric instabilities. On the basis of quasilinear theory the ion heating rate has been obtained and it is shown that the velocity distribution of the ions becomes strongly anisotropic. The results of this investigation are likely to be relevant to the proposed methods using lower hybrid waves for heating plasma ions up to thermonuclear temperatures.

**6147 $CO_2$ laser heating of the plasma behind a reflected shock wave.** Box, S.J.C.; Byszewski, W.W.; John, P.K. (Western Ontario Univ., London (Canada)). pp 339 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

This paper reports temperature changes produced by a TEA $CO_2$ laser in a He plasma. The plasma was produced in an electromagnetic shock tube. The laser output was a 0.3J, 180 nsec pulse. Space averaged spectroscopic measurements of the temperature increase $\Delta T$ as a function of time delay between the shock front and the laser pulse are presented. Typical initial plasma parameters were $n = 3x10^{17}cm^{-3}$ and $T = 2.0eV$ for which $\Delta T$ is approximately 0.4 eV.

**6148 Plasma heating produced by parametric decay instability above the lower hybrid resonance.** Corti, S.; Fontanesi, M.; Grosso, G.; Sindoni, E. (Milan Univ. (Italy). Istituto di Fisica). pp 319 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A parametric decay instability of a pump field in a lower frequency plasma wave and in an ion cyclotron wave has been observed. Electron and ion heating is found in correspondence with the maximum radial amplitude of the decay waves and the dependence of this heating on the pump frequency is studied. A sharp increase of Tsub(e) and Tsub(i) is observed above 20-30 MHz, which is the maximum lower hybrid frequency inside the plasma.

**6149 Investigation of high energy electrons in a beam generated plasma in a magnetic mirror trap.** Fuchs, G.; Herbert, H.C.; Wiesemann, K. (Marburg Univ. (F.R. Germany). Fachbereich Physik). pp 279 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A plasma was generated bt axially injecting an electron beam of 1 to 4keV, 100 mA and 1 to 2mm diameter into a magnetic mirror trap filled with xenon of 0.2...1 mTorr. The emitted microwave and bremsstrahlung roentgen spectra were measured. Two different explanations for the energy gain are discussed. It is concluded that the electron heating mechanism is mainly that of electron cyclotron resonance heating.

**6150 Influence of ions on energy losses of heavy charged particle in a plasma located in a strong high frequency electric field.** Matevosian, H.H. (AN Armyanskoj SSR, Erevan). pp 289 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The influence of ions on polarisation energy losses under strong external field has been considered. The frequency of field is much higher than that of plasma. It is shown that the influence of external field leads to the increasing of energy losses.

**6151 Plasma heating in multiple-resonance excitations.** Siambis, J.G.; Bender, A.D. (Carnegie-Mellon Univ., Pittsburgh, Pa. (USA)). pp 313 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

By applying 1 KW of microwave power at 2.45 GHz and 1 KW of rf power in the frequency range of 4 - 25 MHz at one end of a mirror machine, where neutral hydrogen gas is injected in a pulsed mode, a plasma density of $2 \times 10^{11}/cm^3$ with an electron temperature of 60 eV and ion temperature of 40 eV has been generated. The ion heating mechanism is, principally, collisional thermalization of the applied rf power, via coupling to and excitation of the low frequency resonances of the plasma column.

**6152 Electron heating during Langmuir collapse.** Kingsep, A.S.; Yan'kov, V.V. (Inst. of Atomic Energy, Moscow). *Sov. Tech. Phys. Lett. (Engl. Transl.)*; 1: No. 5, 396-398(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 722-728(1975).

In an analysis of the dissipation of collapsed Langmuir solitons in the case of a constant pump it is shown that the basic dissipation mechanism in this case is Landau damping, accompanied by the formation of a non-Maxwellian hot-electron tail. The total number of particles in the tail is constant over time and independent of the noise generation power.

**6153 Turbulent heating of plasma with a heavy-ion admixture.** Yan'kov, V.V. *Sov. Tech. Phys. Lett. (Engl. Transl.)*; 1: No. 1, 4-5(Jan 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 11-16(12 Jan 1975).

This paper is devoted to a study of the influence of nonlinear effects on the anisotropy of ion-acoustic waves produced by turbulent heating of a plasma with two ion species.

**6154 Ion heating due to magnetosonic waves in a toroidal plasma.** Berezin, A.B.; Vasilevskii, M.A.; Lyubin, V.V.; Roife, I.M.; Seredenko, E.V. (Research Inst. of Electrophysical Apparatus, Leningrad). *Sov. Tech. Phys. Lett. (Engl. Transl.)*; 1: No. 1, 14-15(Jan 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 35-39(12 Jan 1975).

The experiments have shown that there are regimes characterized by a high level of turbulent electric fields. These are the regimes where the strong rf current is produced in a longitudinal magnetic field. The spectrometer measurements of the Stark broadening of the $H\beta$ lines have shown that this current greatly exceeds the threshold determined by the density. The turbulent-field level measured in this manner reaches several kV/cm.

**6155 Plasma heating with multiple ion-cyclotron resonance.** Dolgopolov, V.V.; Hussein, A.M.; Khalil, Sh.M. (Atomic Energy Commission, Cairo (Egypt)). *J. Plasma Phys.*; 14: No. 2, 295-304(Oct 1975).

The electromagnetic field produced by an azimuthal current of arbitrary shape, external to a plasma is considered. In particular, a study is made of the absorption of the field energy by a radially inhomogeneous plasma cyclinder with double ion-cyclotron resonance. Calculations of the power absorbed by plasma ions for an arbitrary ion distribution function are made and it is shown that, in some regions of the plasma it is possible for the work done by the field on the currents to be negative. It is also shown that, if the plasma has regions with a large density gradient (e.g. narrow transitional plasma-vacuum layer), power absorption increases sharply. In addition, the exciting of the natural oscillations of the cylinder by external currents is considered. In this case, power absorption is independent of the dissipative properties of the plasma.

**6156 Tokamak response to relativistic electron beam heating.** Widner, M.M. (Sandia Labs., Albuquerque, N.Mex. (USA)); Dory, R.A. (Oak Ridge National Lab., Tenn. (USA)). *Phys. Lett., A;* 55: No. 1, 33-34(3 Nov 1975).

A Tokamak transport model is used to predict the response to a relativistic electron beam (REB) heating pulse. The REB energy containment time increases with deposited beam energy caused by reduced thermal and particle transport.

**6157 Measurement of the density of rarefield gas and plasma by means of an electron beam.** Zharkova, N.G.; Kuznetsov, L.I.; Rebrov, A.K.; Yarygin, V.N. (Institute of Heat Physics, Siberian Branch, Academy of Sciences of the USSR). *High Temp. (USSR) (Engl. Transl.)*; 14: No. 1, 15-18(Jan 1976).

The possibilities of actively probing rarefied plasma flows with an electron beam are considered. For temperatures of several thousands of degrees the use of the optical part of the spectrum is impeded as a result of the appearance of the plasma recombination continuum. The characteristic x radiation of argon excited by an electron beam is studied in this paper. A method of measuring the local density of rarefied gas and plasma is described; it is based on a measurement of the characteristic radiation intensity. (AIP)

**6158 Dynamics of plasma heating due to the ion-acoustic instability.** Kalmykov, Y.K. *Sov. Phys. - Tech. Phys. (Engl. Transl.)*; 21: No. 3, 276-280(Mar 1976).

A simple model is analyzed for ohmic heating of a plasma in the presence of the ion-acoustic instability. Equations for the electron and ion temperatures are solved analytically for current growth rates which are reasonably large, and they are solved on a computer for the general case. The model is used to describe the plasma heating in a Z pinch. The diffusion of the magnetic field of the current in the presence of the ion-acoustic instability is analyzed. (AIP)

**6159 Quasilinear theory of ion-cyclotron-resonance heating of plasmas and associated longitudinal cooling.** Arunasalam, V. (Plasma Physics Laboratory, Princeton University, Princeton, New Jersey 08540). *Phys. Rev. Lett.;* 37: No. 12, 746-749(20 Sep 1976).

It is shown from a quasilinear theory that an initially isotropic magnetized plasma will be forced into an anisotropic state in ion-cyclotron-resonance heating. Strong heating of the perpendicular ion temperature and strong cooling of the longitudinal temperature should occur simultaneously. The maximum temperature ratio predicted by the quasilinear theory is in exact agreement with that predicted from the basic thermodynamic arguments by Busnardo-Neto, Dawson, Kamimura, and Lin. Heating by fast hydromagnetic waves is also examined. (AIP)

**6160 Mode conversion and plasma column resonances in the ion-cyclotron harmonics range.** Schmitt, J.P.M.; Krumm, P. (Laboratoire de Physique des Milieux Ionises, Ecole Polytechnique, 91120 Palaiseau, France). *Phys. Rev. Lett.;* 37: No. 12, 753-756(20 Sep 1976).

An extraordinary wave is excited in a plasma column with a long rf coil. The plasma absorption exhibits resonances for frequencies below the second ion gyroharmonic ($\omega<2\Omega$/sub i/). The resonances are shown to be similar, in the ion frequency range, to the Buchsbaum-Hasegawa resonances since they originate from a conversion at the lower hybrid layer of the electromagnetic wave into an ion Bernstein wave. Because of hot plasma effects, the short-wavelength converted wave is observed to propagate into the plasma core even for $\omega>2\Omega$/sub i/. (AIP)

**6161 Hydrodynamic efficiency measurements in laser-imploded targets.** Pelah, I.; Goldman, E.B.; Yaakobi, B. (Laboratory for Laser Energetics, University of Rochester, Rochester, New York 14627). *Phys. Rev. Lett.;* 37: No. 13, 829-832(27 Sep 1976).

We have found that numerical simulation and experiment both show laser-imploded spherical glass shells to expand in two successive pulses: The first corresponds to the ablated material, while the second corresponds to the compressed material. The relative speeds and intensities of the two pulses indicate the efficiency of transferring absorbed laser energy to the compressed core. (AIP)

**6162 Resonant electron effects on trapped electron instabilities.** Catto, P.J.; Tsang, K.T.; Callen, J.D.; Tang, W.M. (Department of Mechanical and Aerospace Sciences, University of Rochester, Rochester, New York 14627). *Phys. Fluids;* 19: No. 10, 1596-1598(Oct 1976).

The necessity of distinguishing between perpendicular and parallel components in electron velocity space, rather than simply considering energy, is pointed out and employed to estimate the effects of finite collisionality on the trapped electron instability. (AIP)

**6163 Stability of a high-$\beta$, l=3 stellarator.** Freidberg, J.P.; Grossmann, W.; Haas, F.A. (Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico 87545). *Phys. Fluids;* 19: No. 10, 1599-1607(Oct 1976).

The stability of an infinitely long, high $\beta$, l=3 stellarator is investiated. The calculation is carried out by using the new scyllac expansion in the sharp boundary ideal magnetohydrodynamic model. It is found that for any given size l=3 field allowed by equilibrium considerations and mode number m, an infinite but discrete set of wavenumbers k exist for which the plasma is unstable to all $\beta$; that is, the critical $\beta$ equals zero. These modes can be described as long wavelength interchanges. Thus, with regard to sharp boundary stability, l=3 is less desirable than l=1 for the basic scyllac magnetic field. (AIP)

**6164 Plasma behavior with a separatrix magnetic surface in JFT-2a tokamak.** Shimomura, Y.; Maeda, H.; Ohtsuka, H.; Kitsunezaki, A.; Nagashima, T.; Yamamoto, S.; Kimura, H.; Nagami, M.; Ueda, N.; Funahashi, A.; Matoba, T.; Kasai, S.; Takeuchi, H.; Takahashi, K.; Kumagai, K.; Tokutake, T.; Anno, K.; Arai, T. (Japan Atomic Energy Research Institute, Tokai, Naka, Ibaraki, Japan). *Phys. Fluids;* 19: No. 10, 1635-1640(Oct 1976).

Results from the JFT-2a (DIVA) experiments made with a separatrix magnetic surface are described. The main conclusions are: (1) A separatrix magnetic surface is stably located inside the material surface. (2) A plasma enclosed in a separatrix magnetic surface is similar to that of a conventional tokamak as far as the magnetohydrodynamic properties are concerned. (3) Measured parameters of the main plasma column are consistent with those expected from a conventional tokamak. (4) The electron density and temperature in the scrape-off layer are about ten times less than the values at the center of the main plasma column. (5) Heat and particle fluxes to the divertor region are axisymmetric and several times less than those of the total loss fluxes from the main plasma column. (6) Runaway electrons are well guided to the divertor region. (AIP)

## PLASMA DIAGNOSTICS

*REFER ALSO TO CITATION(S) 6229, 6231*

**6165 (UCRL—77743) Time resolved x-ray pinhole photography of compressed laser fusion targets.** Attwood, D.T. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 26 Jul 1976. Contract W-7405-Eng-48. 9p. (CONF-760828—8). Dep. NTIS $3.50.

From 12. international congress on high speed photography; Toronto, Canada (1 Aug 1976).

Use of the Livermore x-ray streak camera to temporally record x-ray pinhole images of laser compressed targets is described. Use is made of specially fabricated composite x-ray pinholes which are near diffraction limited for 6 A x-rays, but easily aligned with a He—Ne laser of 6328 A wavelength. With a 6 $\mu$m x-ray pinhole, the overall system can be aligned to 5 $\mu$m accuracy and provides implosion characteristics with space—time resolutions of approximately 6 $\mu$m and 15 psec. Acceptable criteria for pinhole alignment, requisite x-ray flux, and filter characteristics are discussed. Implosion characteristics are presented from our present experiments with 68 $\mu$m diameter glass microshell targets and 0.45 terawatt, 70 psec Nd laser pulses. Final implosion velocities in excess of $3 \times 10^7$ cm/sec are evident.

**6166 (UCRL—77744) Ultraviolet probing of laser produced plasmas with picosecond pulses.** Attwood, D.T.; Coleman, L.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 21 Jul 1976. Contract W-7405-Eng-48. 10p. (CONF-760828—6). Dep. NTIS $3.50.

From 12. international congress on high speed photography; Toronto, Canada (1 Aug 1976).

Technical photography, through such means as interferometry, Faraday rotation, and simple shadowgraphs, can provide significant data for understanding the absorption and transport of energy within laser produced plasmas. For plasmas produced by intense, sub-nanosecond Nd laser pulses, one is required to study electron densities in the $10^{20}$ to $10^{21}$ e/cc range, with density contour velocities of $10^6$ to $10^7$ cm/sec, and axial scale lengths of 1-20 $\mu$m. The relationship between these plasma parameters and the requisite photographic system is described. It is concluded that the system requires a probe wavelength in the middle ultraviolet, a pulse duration in the 10-100 picosecond regime, and large numerical aperture optics corrected for spherical aberrations. Results obtained at 2660 A with holographic microinterferometry, Faraday rotation, and shadowgraphs are presented.

**6167 (UCRL—78422) Picosecond x-ray spectral studies.** Attwood, D.T.; Coleman, L.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 21 Jul 1976. Contract W-7405-Eng-48. 9p. (CONF-760828—7). Dep. NTIS $3.50.

From 12. international congress on high speed photography; Toronto, Canada (1 Aug 1976).

Temporally and spectrally resolved x-ray emission is an important diagnostic tool for the study of target heating and compression induced by sub-nanosecond laser pulses. The use of the Livermore 15 psec x-ray streak camera to record x-ray emissions in the 1-10 keV range is described. In particular, significant progress is reported during the past year in defining the camera as a quantitative diagnostic instrument, and its implementation for multi-channel, time resolved K-edge filter measurements. Data will be presented which describe x-ray emission from a laser imploded 87 $\mu$m diameter glass shell. Channels centered at 2.6, 4.0 and 5.3 keV provide temporal information which is related to the absorption and compression phases of laser heating. The relative spectral content is found to be in agreement with standard, time integrated measurements.

**6168 Charge-carrier density of the plasma produced in a penning mixture by irradiation by uranium fission fragments and reactor radiation.** Batyrbekov, G.A.; Kuznetsov, Yu.D.; Takibaev, Zh.S. *Sov. Phys. - Tech. Phys. (Engl. Transl.);* 19: No. 5, 645-646(Nov 1974).

This article reports on the construction of apparatus suitable for plasma diagnostics within a reactor and a study of the plasma produced in a Penning mixture in ionization caused by uranium fission fragments and reactor radiation.

**6169 Electrostatic probe diagnostics of plasma jet at atmospheric pressure.** Ivanov, Yu.A.; Oliver, D.H.; Ovsyannikov, A.A.; Pihlak, U.L.; Polak, L.S. (Institute of Petrochemical Synthesis, Moscow, USSR). pp 203 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

An electrostatic probe has been used to measure the electron temperature, ion density and its fluctuations in a steady free plasma jet under atmospheric pressure.

**6170 Submillimeter plasma interferometry at two wavelengths.** Kutovio, V.D.; Petrov, G.D.; Samarskii, P.A.; Tregubov, S.I. (All Union Scientific-Research Inst. of Physicotechnical and Radiotechnical Measurements, Moscow). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 470-471(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 857-860(1975).

A pulsed submillimeter laser operating at wavelengths of 118 and 337 $\mu$ was used in an interferrometric determination of the electron density in the positive column of an arc discharge in argon. Pressures from 1 to 3 torr and discharge currents from 8 to 32 A were studied. The refractive indices of air, methane, hydrogen, and argon at pressures in the range 0.2 to 0.1 atm were measured at the same wavelengths.

**6171 Forbidden transitions induced by collisions in a dense plasma.** Vinogradov, A.V.; Yukov, E.A. (Lebedev Inst. of Physics, Moscow). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 472-473(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 860-862(1975).

The intensity and shape of the forbidden lines induced by collisions with charged particles are investigated. The intensity of these lines turns out to be proportional to the temperature T/sub i/ and the density N/sub i/ of the ion component of the plasma, so that observation of these lines at a sufficiently high density (N/sub i/ greater than or approximately greater than $10^{19}$ cm$^{-3}$) can be used for diagnostic purposes.

**6172 Interference-hologram investigation of a plasma in the vicinity of a neutral current layer.** Dreiden, G.V.; Zaidel, A.N.; Markov, V.S.; Mirzabekov, A.M. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 2, 68-69(Feb 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 141-146(12 Feb 1975).

An investigation of the distribution of the electron density in a plasma which contains a neutral current layer is described. These results are of considerable interest in assessing the possibilities of conversion of the magnetic energy of a current layer into kinetic energy of accelerated particles. The investigations have been performed on the TS-3 device. This device consists of strong-current straight discharge in a two-dimensional quadrupole magnetic field.

**6173 Theory of the mutual impedance of two small dipoles in warm isotropic plasma.** Pottelette, R.; Rooy, B. (Centre National de la Recherche Scientifique, 94 - Saint-Maur-des-Fosses (France). Groupe de Recherches Ionospheriques); Fiala, V. *J. Plasma Phys.*; 14: No. 2, 209-243(Oct 1975).

It is shown theoretically that the electron density and temperature of a piasma could be deduced from the measurements of the transfer impedance between two small dipole antennae, each much shorter than a Debye length, separated by a distance of ten or more Debye lengths. In contrast to the quadripole probe, the 'double-dipole probe' relies on not producing perturbations in the plasma, rather than on minimizing their effects. The plasma is assumed to be warm and isotropic, and the motion of the ions is neglected. First, it is shown that, in a Maxwellian plasma, the frequency response of a double-dipole probe is easier to interpret than that of a quadripole probe with the customary square layout. Then, in a second step, the transfer impedance of the former probe is calculated in a Cauchy plasma, and the results are compared with those previously obtained in a Maxwellian plasma. By so doing, it is shown that, for large distances between the dipoles, the real part of the transfer impedance is sensitive to the form of the tail of the distribution function.

**6174 Method for measuring the heavy stripped ion abundances of plasma.** Briand, P.; Geller, R.; Theiss, A. (CEA Centre d'Etudes Nucleaires de Grenoble, 38 (France). Dept. de la Physique du Plasma et de la Fusion Controlee). *Nucl. Instrum. Methods*; 129: No. 1, 19-26(1 Nov 1975).

A description is given of a system which uses a velocity filter and an energy filter in tandem to analyze the abundances and energy spreads of highly stripped ions. The system can also serve as a plasma diagnostic.

**6175 A technique for the measurement of electron density in a rotating plasma.** Das, G.C. (Indian Inst. of Science, Bangalore. Dept. of Applied Mathematics). *Int. J. Electron.*; 39: No. 6, 635-636(Dec 1975).

A theroetical outline of a method for the measurement of electron density in a rotating plasma is given. The method is based on the measurement of the Faraday rotation produced by the Coriolis force.

**6176 Review of diagnostics for laser-pellet interaction experiments.** Woodall, D.M.; Yaakobi, B.; Lubin, M.J. pp 191-250 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

Experimental studies of the laser fusion interaction process are divided into three classes: plasma physics, hydrodynamic energy transport, and core compression. This organization includes a natural progression from the surface effects due to the interaction of the laser pulse with the fuel, through the hydrodynamic energy transfer in the fuel pellet, to the compression and heating of the fuel core. Different techniques for x-ray diagnostics are described along with charged particle collection methods. (MOW)

**6177 Laser fusion: diagnostics and experiments.** McCall, G.H. In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

The following topics are described: (1) nuclear reaction product diagnostics, (2) x-ray spectroscopy, (3) ion diagnostics, (4) interferometry, (5) streak photography, (6) x-ray imaging, (7) basic experiments, (8) corona neutrons, and (9) implosion experiments. (MOW)

**6178 Measurement of the spatial profile of the electron density in a magnesium laser plasma by determining the Stark broadening in the x-ray region of the spectrum.** Bayanov, V.P.; Gulidov, S.S.; Mak, A.A.; Peregudov, G.V.; Sobel'man, I.I.; Starikov, A.D.; Chirkov, V.A. (P. N. Lebedev Physics Institute, USSR Academy of Sciences). *JETP Lett. (USSR)* (*Engl. Transl.*); 23: No. 4, 17-20(20 Feb 1976).

We investigated the Stark broadening of the 1s—5p ($\lambda$ =6576 A) line of the hydrogen-like ion MgXII in the x-ray emission spectrum of a laser plasma. The energy of the heating laser pulse was E=25 J, the duration was tau=$10^{-10}$ sec, and $\lambda$=1.06 $\mu$. From the magnitude of the Stark broadening we constructed the dependence of the electron density N/sub e/ of the plasma on the distance to the target. The maximum value of N/sub e/, measured near the target, was 3.1—$10^{21}$ cm$^{-3}$. The spatial resolution of the laser flare was 25 $\mu$. (AIP)

**6179 Resolution of thin foils used in particle diagnostics of plasmas.** Kurnaev, V.A. (Moscow Engineering Physics Institute). *Sov. Phys. - Tech. Phys.* (*Engl. Transl.*); 21: No. 3, 363-364(Mar 1976).

The dependence of the energy resolution of thin foils used in plasma diagnostics on the foil thickness and on the foil stopping power is calculated. (AIP)

**6180 Neutron emission from a turbulently heated high-voltage theta-pinch plasma.** Chen, Y.G. (Department of Physics and Astronomy, University of Maryland, College Park, Maryland 20742). *Phys. Rev. Lett.*; 37: No. 11, 703-706(13 Sep 1976).

Spatial and temporal origins of three distinct neutron emission peaks observed in the University of Maryland turbulently heated high-voltage theta pinch machine have been identified. They are the result of fusion reactions involving reflected hot deuterium ions, pinched plasma, and energetic ions colliding with deuterium absorbed on the vacuum vessel wall, respectively. Studies of the wall-interaction neutron peak further reveal that the particle end loss in the reversed-field case is substantially slower than in the parallel-field case. (AIP)

**6181 Nonlocal effects in the electrostatic ion-cyclotron instability.** Stern, R.A.; Correll, D.L.; Bohmer, H.; Rynn, N. (Bell Laboratories, Murray Hill, New Jersey 07974). *Phys. Rev. Lett.*; 37: No. 13, 833-836(27 Sep 1976).

High-resolution tunable laser resonance diagnostics reveal ion density decreases within the unstable region of an ion-cyclotron wave as well as hot-ion transport out of the unstable region, showing that instability and heating are dominated by a nonlocal process combining ion transport with heating. (AIP)

**6182 Observation of inverted population levels in the FM-1 spherator.** Suckewer, S.; Hawryluk, R.J.; Okabayashi, M.; Schmidt, J.A. (Plasma Physics Laboratory, Princeton University, Princeton, New Jersey 08540). *Appl. Phys. Lett.*; 29: No. 9, 537-539(1 Nov 1976).

Inversions in the population of excited levels in hydrogen and He II were observed in the FM-1 spherator. The inversion increases strongly as the ratio of the decay time of the electron temperature to the decay time of the electron density was decreased. Time-dependent numerical calculations of the populations were in good agreement with the experimental measurements. More general calculations for high-Z hydrogenlike ions are discussed. (AIP)

## PLASMA KINETICS - GENERAL

*REFER ALSO TO CITATION(S) 6237*

**6183** (LA-UR—76-1687) **Pulsed laser stereo photography of electrically exploded bridges.** Seitz, W.L.; Gardner, S.D. (Los Alamos Scientific Lab., N.Mex. (USA)). 1976. Contract W-7405-Eng-36. 8p. (CONF-760832—10). Dep. NTIS $3.50.

From 20. annual SPIE technical symposium; San Diego, California, United States of America (USA) (23 Aug 1976).

A technique is described for obtaining short exposure (approximately 8 ns) high resolution photomicrographs of electrically exploded bridges using a pulsed laser for bridge illumination and band-pass filters to eliminate the intense self light. Two cameras are described, one for a small field of view (approximately 1 mm) and one for a relatively large field of view (approximately 20 mm). A carbon disulfide cell and a fiber-optic light guide are used to essentially eliminate speckle, which normally limits the resolution of laser photographs of diffuse surfaces. A series of photomicrographs showing the detailed burst characteristics of both flat and round bridges are shown.

**6184** **Anomalous energy loss of a plasma traveling in a uniform magnetic field.** Kishimoto, H.; Ushio, M.; Ito, H. (Osaka Univ.). *J. Phys. Soc. Jpn.*; 37: No. 6, 1637-1643(Dec 1974).

A theta pinch gun is operated to get a plasma stream in a longitudinal magnetic field which is uniform over a region of 1 m in length. The loss rate of the transverse energy of a plasma stream is proportional to the so-called Bohm diffusion rate for both deuterium and helium plasmas.

**6185** **Electrode phenomena in low voltage arc in alkaline metal vapour.** Baksht, F.G.; Djuzhev, G.A.; Mitrofanov, N.A.; Tsirkel, B.I.; Shkolnik, S.M.; Yuriev, V.G. (AN SSSR, Leningrad. Fiziko-Tekhnicheskij Inst.). pp 125 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Plasma and near-electrode regions of low voltage cesium arc (Psub(cs)=$10^{-2}$-4 torr) were investigated at high current densities (up to 100 a/cm$^2$) by probe and spectral techniques. It was shown that a mode of discharge is determined by relation between an anode current density jsub(a) and a random one jsub(r) in plasma. The connection of near-electrode drops with plasma parameters was studied. The conditions of anode spot formation was also considered.

**6186** **Electron beam radiation in the inhomogeneous plasma waveguide.** Rogashkova, A.I. (AN SSSR, Moscow. Inst. Radiotekhniki i Ehlektroniki). pp 281 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

It is shown that in metal waveguide, filled by cold, inhomogeneous plasma the modulated electron beam radiates fast electromagnetic waves. The radiation efficiency depends on direction of beam motion relatively to concentration gradient.

**6187** **Measurement of the electric field of a rotating plasma.** Konstantinov, S.G.; Tsel'nik, F.A. (Inst. of Nuclear Physics, Novosibirsk, USSR). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 439-441(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 802-805(1975).

The radial profile of the electric potential has been measured in plasmas with densities up to $10^{13}$ cm$^{-3}$ rotating in magnetic mirrors.

**6188** **Boundary layer between a rotating plasma and a neutral gas blanket.** Hellsten, T.; Raggi, R. (Kungliga Tekniska Hoegskolan, Stockholm (Sweden)). *Nucl. Instrum. Methods;* 129: No. 1, 11-18(1 Nov 1975).

The boundary layer situated between a rotating hydrogen plasma of high density and a surrounding neutral gas blanket has been investigated by means of electric probes. The measured parameters are the electric field, the plasma density, and the electron temperature. The surface generated by the magnetic field lines touching the cathode plate acts as a strong plasma sink. Outside this surface a dilute plasma has been detected. The behaviour of the partially ionized region and its boundaries is in agreement with theoretical deductions.

**6189** **Plasma—neutral gas boundary layers.** Lehnert, B. (Kungliga Tekniska Hoegskolan, Stockholm (Sweden)). *Nucl. Instrum. Methods;* 129: No. 1, 31-37(1 Nov 1975).

The plasma—neutral gas balance is considered in the partially ionized transition region situated between a fully ionized magnetically confined plasma and an adjacent neutral gas cloud. A well-defined boundary layer can develop between the plasma and the neutral gas, but only within certain ranges of the relevant parameters such as the plasma density and the magnetic field strength. Consequently, such layers are expected to appear in the atmospheres of normal and magnetic variable stars and in other more dense cosmic clouds of matter, as well as in impermeable laboratory plasmas. On the other hand, sharply defined boundary layers are unlikely to appear in the low-density regions of interstellar and interplanetary space where the plasma becomes permeable to neutral gas and the partially ionized transition region has a minimum depth of the order of 5 x $10^{18}$/n/sub b/m, where n/sub b/ is the corresponding characteristic plasma density.

**6190** **Hydrodynamic free expansion of a localized relativistic plasma.** Vitello, P.; Salvati, M. (Department of Physics, Cornell University, Ithaca, New York 14853). *Phys. Fluids;* 19: No. 10, 1523-1531(Oct 1976).

A hydrodynamical treatment of the free expansion into vacuum by a relativistic plasma with an embedded magnetic field is presented. Both a linear and a spherical geometry are considered. For times when the system has expanded to sizes much larger than the initial size the energy density, number density, velocity, and magnetic field profiles are given. The general features of relativistic free expansion are discussed and compared with those of nonrelativistic free expansion. (AIP)

**6191** **Diffusion in velocity space associated with nonadiabatic changes in the magnetic moment of a charged particle.** Bernstein, I.B.; Rowlands, G. (Lawrence Livermore Laboratory, University of California, Livermore, California 94550). *Phys. Fluids;* 19: No. 10, 1546-1550(Oct 1976).

A kinetic equation is derived which includes velocity space diffusion effects due to nonadiabatic jumps in the magnetic moment. This extra diffusion can be comparable to classical diffusion in experimental situations of interest. (AIP)

**6192** **High conductivity magnetic tearing instability.** Cross, M.A.; Van Hoven, G. (Physics Department, Grambling College, Grambling, Louisiana 71245). *Phys. Fluids;* 19: No. 10, 1591-1595(Oct 1976).

The field-reconnection instability of a magnetic neutral sheet is studied using magnetohydrodynamic theory, including the electron-inertia term in Ohm's law. The behavior is described for the full range of the Coulomb-resistivity vs collisionless skin-depth parameter zeta=$10^{30}$/sup ./$^3$B T$^1$/sup ./$^2$/lnΛ) a$^2$/sup ./$^5$ n$^2$/sup ./$^2$ (cgs), describing the field reversal. Such long-wavelength tearing can occur over a wide span of physical conditions from those of solar active regions (zetavery-much-less-than1) to those in the geomagnetic tail (zetavery-much-greater-than1). In particular, the growth rate of the infinite-conductivity instability may be expressed as ω=$10^{20}$/sup ./$^3$B/a$^2$/sup ./$^3$n$^1$/sup ./$^3$, for a hydrogen plasma. In this limit, the time scale of auroral development is found to be $10^3$/sup ./$^3$ sec, a value close to that observed. The regime of applicability of this formulation is also discussed, and the results are compared with those obtained by other methods, including the Vlasov equation. (AIP)

## PLASMA KINETICS - EXPERIMENTAL

*REFER ALSO TO CITATION(S) 4977*

**6193** **Plasma-focused radiation in the vacuum ultraviolet region.** Zvorykin, V.D.; Kashnikov, G.N.; Kekmentov, A.D. (Moscow Technical Coll.). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 4, 169(Apr 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 359-362(26 Apr 1975).

With the aid of an open ionization chamber, an investigation was made of the emission spectrum of the plasma focus of a magnetoplasma compressor of the erosion type. The discharge parameters are I/sub max/ approximately 200 to 240 kA, tau/sub av/ approximately 20 μsec, N/sub e/ = 7 x $10^{17}$ to 5 x $10^{18}$ cm$^{-3}$, T/sub e/ = 3 to 6 eV, $C_0$ = 756 μF, $E_0$ = 3 to 5 kV, and eta/sub en/ approximately 0.8.

## PLASMA KINETICS - THEORETICAL

**6194** (COO—2456-36) **Numerical solution of the axisymmetric magnetohydrodynamic equilibrium equation.** Reusch, M.F. (Columbia Univ., New York (USA). Plasma Lab.). 1976. Contract E(11-1)-2456. 148p. Dep. NTIS $6.00.

Thesis.

The MHD equilibrium equation, for axisymmetric systems, as given by H. Grad and V. D. Shafranov, is described in cylindrical coordinates. The Dirichlet problem for this elliptic, mildly nonlinear, partial differential equation, in a finite domain of solution is studied. Conditions for the existence and uniqueness of solutions to this problem are discussed. A lower bound on a parameter in the equation, below which bifurcation cannot occur, is derived. The behavior of a simple type of solution is analyzed. Several iteration methods for the numerical solution of the problem are presented and their convergence discussed. A fixed minimum constraint method for consistently finding several nonunique solutions to the problem is given. A one point approximation estimate is developed for the prediction of the occurrence of nonuniqueness and the number of nonunique solutions. A 1-D model problem, which is nonunique and exactly soluble, and for which a numerical iteration procedure is also soluble at every stage, is discussed in detail.

**6195** (COO—2735-1) **Studies of tokamak fusion reactor dynamics. Progress report, June 1, 1975—February 15, 1976.** Mills, R.G.; Gralnick, S.L. (Princeton Univ., N.J. (USA). Plasma Physics Lab.). 1976. Contract E(11-1)-2735. 7p. Dep. NTIS $3.50.

An investigation of the effect of plasma shape and position on the inductive coupling between the plasma and the external poloidal field coils is briefly described. Research on a multi-node time-dependent point kinetics code with which to study the operating dynamics of a tokamak reactor is also mentioned. (MOW)

**6196** (ORNL/TM—5599) **Global properties of high pressure flux conserving tokamak equilibria.** Clarke, J.F.; Sigmar, D.J. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 25p. Dep. NTIS $3.50.

An approximate analytic theory is developed to calculate the poloidal beta $\beta$/sub I/ and the diamagnetic parameter $\mu$/sub I/ for a sequence of axisymmetric toroidal MHD equilibria confining high pressure plasmas [$\beta$ approximately theta(a/R)] under the constraint of flux conservation. To satisfy the equilibrium equations, the plasma current must be increased with pressure as p/sup 1/3/ and previously calculated equilibrium limits on poloidal beta are avoided.

**6197 Spatial relaxation of wall electrons in a plasma.** Ecker, G.; Riemann, K.U.; Scholz, A. (Bochum Univ. (F.R. Germany). Inst. fuer Theoretische Physik). pp 234 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The problem of the relaxation of wall electrons into a plasma is of interest as well in gaseous electronics as in the field of fusion technology. Previous investigations consider the energy relaxation only assuming that the angular relaxation occurs on a much smaller scale. Mathematically this assumption means a considerable simplification.

**6198 Anomalous diffusion and turbulence in high-beta plasmas penetrating magnetic fields.** Koopman, D.W. (Maryland Univ., College Park (USA). Inst. for Fluid Dynamics and Applied Mathematics). pp 329 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A laser-produced plasma is allowed to expand in a low density ionized environment containing a 700 gauss field. Experimental measurements of the distortion, compression, and recovery of the magnetic field are compared to predictions of a theoretical model. Satisfactory agreement is obtained only when anomalously large diffusion coefficients are assumed, indicating an effective plasma resistivity 10 to 100 times greater than the classical value. Direct evidence of turbulence is also seen on diagnostic probes.

**6199 Kinetic equation of electrons for a weakly ionized plasma in a strong magnetic field.** Krinberg, I.A. (AN SSSR, Irkutsk. Sibirskij Inst. Zemnogo Magnetizma Ionosfery i Rasprostraneniya Radiovoln). pp 269 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Kinetic equation for the guiding center distribution function of the electrons in a weakly ionized plasma in a strong magnetic field is obtained. The collision term of this equation is calculated to zero order in the ratio of the electron-neutral particle collision frequency to the electron gyro frequency by averaging the Lorentz gas approximation to the Boltzmann collision operator over electron phase.

**6200 Drift-kinetic equation in the presence in HF field.** Milantiev, V.P. (Patrice Lumumba Univ., Moscow, USSR). pp 268 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The drift-kinetic equation for a rarefied plasma in the presence of a HF field is obtained, cyclotron resonance conditions being excluded.

**6201 Non-ideal plasma electrical conductivity.** Norman, G.E.; Valuev, A.A. (Institute of High Temperatures, USSR Academy of Sciences, Moscow, USSR). pp 257 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Calculations are presented of the velocity autocorrelation function and the electrical conductivity of fully ionized dense plasma at Debye numbers about $10^{0}$—$10^{-1}$. Use is made of molecular dynamics and Monte Carlo methods. The results obtained agree with experimental data available.

**6202 Transport properties of a two temperature fully ionized plasma.** Oeien, A.H. (Bergen Univ. (Norway)). pp 265 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A plasma model has been studied where electrons and ions are allowed to have different temperatures, and the effect of the electron-ion temperature difference on the transport properties has been found in particular. Depending on the sign of the electron-ion temperature difference and the gradient thereof, transports of momentum and energy are set up which will either enhance or weaken the 'classical' results.

**6203 Distribution of microfields in non-ideal plasma.** Podlubny, L.I.; Trigger, S.A. (Institute of High Temperatures, USSR Academy of Science, Moscow, USSR). pp 259 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A new analytical expression for the function of microfield distribution in non-ideal plasma is obtained. In addition to the Coulomb interaction effect, this expression takes account for the presence of the short-range part of the electron-ion and ion-ion potentials.

**6204 Computer simulation of a two-dimensional Langmuir turbulence.** Polyudov, A.N.; Sigov, Yu.S. (AN SSSR, Moscow. Inst. Prikladnoj Matematiki). pp 332 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A nonlinear evolution of the large amplitude electrostatic plasma wave is investigated by two-dimensional numerical experiments. Kinetic phenomena connected with the self-focusing of Langmuir oscillations are examined. An expression for the effective collision frequency, the electron and ion distribution functions and 2d strong turbulence spectra are obtained.

**6205 Microfield distribution evaluated from the dynamic screening model.** Schumacher, A. (Bochum Univ. (F.R. Germany). Inst. fuer Theoretische Physik). pp 258 of In Phenomena in ionized gases. vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The author justifies the separation of the total microfield distribution into a low and a high frequency component and the calculation of these components from a model of uncorrelated, dynamically screened particles. The evaluation of the low frequency component, which is of prominent interest for applications, yields results which show deviations from all earlier theories.

**6206 Ordering scheme for the collision integrals of the moment method; energy balance as example.** Weinert, U. (Duesseldorf Univ. (F.R. Germany). Inst. fuer Theoretische Physik). pp 266 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The nonlinearized collision integrals of the balance equation for a multi-temperature plasma are expressed in terms of normal-

ized temperature differences and transport collision frequencies. These are used to estimate the order of magnitude of the collision integrals.

**6207 Model of dense non-ideal plasma.** Yermokhin, N.V.; Kovaliov, B.M.; Kulik, P.P. pp 184 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A chemical model taking account of plasma non-ideality and cluster formation is considered for the calculation of dense plasma thermodynamical properties. The results are in good agreement with experimental data. The evidence of the generation of negative clusters with an electron binding energy of 1-2 ev is proved for cesium dense plasma. For this case clusters concentrations are computed.

**6208 Interaction of ion beams with plasmas.** Ivanov, A.A.; Krasheninnikov, S.I.; Soboleva, T.K.; Yushmanov, P.N. (Inst. of Atomic Energy, Moscow). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 412-417(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 753-764(1975).

In an analysis of the nonlinear stage of the interaction of an ion beam with a collisionless plasma for various ratios of the beam velocity and the ion-acoustic velocity it is found that the interaction takes quite different forms in two limiting cases: In the case $v_0$ much greater than c/sub s/ deflection of the beam without an energy loss predominates, but in the case $v_0$ less than or approximately less than c/sub s/ there is intense energy transfer to the plasma. The scale times for the energy transfer are found for the case $v_0$ less than or approximately less than c/sub s/ and the rate of the beam turning is found for the case $v_0$ much greater than c/sub s/.

**6209 Perturbation of plasma and electric field near a slowly moving point object.** Dubovoi, A.P.; Moskalenko, A.M.; Strizhekozin, Yu.A.; Yaroslavtsev, A.A. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio-Wave Propagation, Moscow). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 434-438(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 793-801(1975).

In a study of the perturbation of a low-density plasma by a point charged object, the object is assumed moving slowly in comparison with the ion thermal velocity. The kinetic equations and the Poisson equation are used. The problem is solved through an integration of the kinetic equations along the phase trajectories of the particles in the field of an object at rest. Analytic expressions for the electrostatic potential and the particle density are derived and analyzed. The results are compared with the results of perturbation theories. The results are also displayed as computer-generated curves.

**6210 Evolution of the distribution function of ions produced in a steady-state thermonuclear reaction.** Kolesnichenko, Ya.I.; Fursa, A.D. (Inst. of Nuclear Research, Novosibirsk, USSR). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 442-445(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 806-813(1975).

In a study of the time evolution of the distribution function of the thermonuclear-reaction products ($\alpha$ particles) caused by the scattering of these particles by plasma electrons and ions, an equation is found for the $\alpha$ distribution function in the steady state. This equation holds for both isothermal and nonisothermal plasmas. Even if there are only relatively few $\alpha$ particles in the plasma, the pressure caused by the $\alpha$ particles of the tail of the distribution function can amount to an important part of the plasma pressure.

**6211 Kineticheskaya teoriya neideal'nogo gaza i neideal'noi plazmy. (Kinematic theory of non-ideal gases and non-ideal plasmas).** Klimontovich, Yu.L. Moscow; Izdatel'stvo Nauka (1975). 352p.

This book gives a systematic presentation on the kinetic theory of a nonideal gas and of a nonideal plasma. The main attention is devoted to presenting the most recent results. Traditional material is presented only to the extent required for creating a complete picture of kinetic processes in nonideal systems. A good deal of attention is devoted in particular to the kinetic theory of large-scale fluctuations, that is, to fluctuations with correlation times on the order of or greater than the times of a mean free path length and with correlation lengths on the order of or greater than the length of a mean free path. The taking into account of large-scale fluctuations is necessary for example in constructing the kinetic equations for dense gases and plasma and in describing a turbulent plasma. The book consists of three parts: (1) kinetic theory (classical) of a nonideal gas; (2) kinetic theory (classical) of a nonideal plasma which is completely ionized, and (3) quantum kinetic equations for a nonideal gas and a nonideal plasma. The last chapter in the book deals with the kinetic theory of chemically reacting gases and of a partially ionized plasma. 2 figures, 176 references. (SJR)

**6212 Rapid compression of strong-current relativistic electron beam in a gas.** Agafonov, A.V.; Lebedev, A.N. (Lebedev Inst. of Physics, Moscow). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 1, 16-17(Jan 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 40-44(12 Jan 1975).

A numerical study was made of a cylindrically symmetrical relativistic electron beam with zero emittance in an initially nonionized gas. It is assumed that the beam density changes little in the propagation direction z over distances on the order of the transverse deviations of the particles from the axis. This means at the same time that the transverse velocity component v/sub r/ is small in comparison with the longitudinal velocity v/sub z/, and that the longitudinal fields are weak. The system of equations describing the behavior of the beam density with time and the kinetics of ion accumulation is given.

**6213 Dynamics of a one-dimensional magnetoactive plasma.** Laptukhov, A.I. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 3, 137-138(Mar 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 285-288(26 Mar 1975).

Assume that in a magnetic field Vector B = (0, 0, B) there is a one-dimensional (delta/delta y = 0 = delta/delta z, delta/delta x not equal to 0) collisionless plasma. The dynamics of the compression of such a plasma by an external magnetic field are considered. The analysis is based on the single-fluid model with a Hall effect, which is considered together with Maxwell's equations.

**6214 Re-normalization in the theory of weak turbulence in plasmas.** Vaclavik, J. (Fribourg Univ. (Switzerland). Inst. de Physique). *J. Plasma Phys.*; 14: No. 2, 315-325(Oct 1975).

The paper compares the methods of re-normalization introduced by the Dupree-Weinstock theory of turbulence with those in the theories of Kadomtsev, Rudakov and Tsytovich. It is shown to what extent they are equivalent.

**6215 Analytic solution of the helical equilibrium equation in the MHD approximation.** Woolley, M.L. (UKAEA Research Group, Abingdon. Culham Lab.). *J. Plasma Phys.*; 14: No. 2, 305-314(Oct 1975).

The second-order elliptic partial differential equation, which describes a class of static ideally conducting magnetohydrodynamic equilibria with helical symmetry, is solved analytically. When the equilibrium is contained within an infinitely long conducting cylinder, the appropriate Dirichlet boundary-value problem may be solved in general in terms of hypergeometric functions. For a countably infinite set of particular cases, these functions are polynomials in the radial co-ordinate; and a solution may be obtained in a closed form. Necessary conditions are given for the existence of the equilibrium, which is described by the simplest of these functions. It is found that the Dirichlet boundary-value problem is not well-posed for this equilibria; and additional information (equivalent to locating a stationary value of the hydrodynamic pressure) must be provided, in order that the solution be unique.

**6216 Variational calculation of the energies of atoms and ions in a plasma.** Podlubnyi, L.I. (Moscow Energy Inst.). *Dokl. Akad. Nauk SSSR;* 224: No. 5, 1056-1058(11 Oct 1975). (In Russian).

A look is taken at a bound pair of charged particles immersed in an equilibrium, dense system of classical scattering centers. Interaction with a thermostat leads to a change in the energy spectrum of atoms and ions. If the perturbation energy is not large in comparison with $kT = 1/\beta$, the shifts in energy $\Delta E$, the change in free energy F and other characteristics of the atom or ion in the dense medium can be calculated by means of the thermodynamic theory of perturbations. A method of functional integrals is used to calculate F. In the case of strong binding it is found that the variational method gives good results. This method can be used for calculating the energies of atoms, positive and negative ions in a dense gas or gas-discharge plasma, the energies of an exiton or impurity center in an electron-hole plasma, of an ionic molecule in a strong electrolyte, etc. The variational method can without difficulty be generalized also to a multielectron system immersed in a quantum thermostat. 4 refs. (SJR)

**6217 Long-time tails in a one component plasma.** Baus, M.; Wallenborn, J. (Brussels Univ. (Belgium)). *Phys. Lett., A;* 55: No. 2, 90-91(17 Nov 1975).

Oscillatory long-time tails are obtained for the shear viscosity of a one component plasma from a microscopic theory. The non-analytic expansion in $k^2$ of the shear mode is also given.

**6218 Approximate Fokker—Planck collision operator for transport theory applications.** Hirshman, S.P.; Sigmar, D.J. (Massachusetts Institute of Technology, Cambridge, Massachusetts 02139). *Phys. Fluids;* **19**: No. 10, 1532-1540(Oct 1976).

An analytically tractable approximation is developed for the linearized Fokker—Planck collision operator describing a plasma nearly in thermal equilibrium. This approximate operator preserves the symmetry properties of the exact collision integral which imply the physical conservation laws, self-adjointness, and the H theorem. A renormalization procedure is developed to accurately treat collisions between particles of arbitrary masses. For large or small mass ratios, the approximate operator reduces to the standard expansions of the exact operator. In the case of identical particle collisions, the present approximation provides a significant improvement over the "model operator" previously given in the literature, yet retains the simplicity of former operators necessary for analytic work. The recalculation of the classical transport coefficients with this operator reduces to the solution of a coupled set of algebraic equations and indicates its reliability for use in complex neoclassical transport situations. The neoclassical electrical conductivity calculation demonstrates the new physical features of the approximate operator. (AIP)

**6219 Exact Vlasov—Maxwell equilibria with sheared magnetic fields.** Channell, P.J. (Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720). *Phys. Fluids;* **19**: No. 10, 1541-1545(Oct 1976).

A theoretical formalism which allows the generation of a large class of exact Vlasov—Maxwell equilibria with sheared magnetic fields is presented. All quantities are assumed to vary in only one spatial direction, x, and the magnetic field has components only in the y and z directions. The Vlasov equations are solved by making the distribution functions depend only on constants of the motion. The Maxwell equations are then reduced to finding the motion of a pseudo-particle in a two-dimensional potential. Three examples corresponding to sheet-like, sheath-like, and wave-like equilibria are presented. (AIP)

**6220 Investigation of plasma turbulence by modified analysis of scattered laser light.** Maurmann, S.; Finken, K.H.; Kunze, H. (Institut fur Experimentalphysik, Ruhr-Universitat, 463 Bochum, West Germany). *Phys. Fluids;* **19**: No. 10, 1551-1553(Oct 1976).

It is suggested, that the mean square deviation of measured values of the spectrum of scattered light from the best fit (Gaussian) curve is correlated with the level of plasma turbulence. Results indicate that after excitation an ion acoustic turbulence decays on a time scale of ion—ion collisions. (AIP)

**6221 Vlasov equilibrium and electrostatic stability properties of a nonrelativistic nonneutral E layer.** Davidson, R.C.; Uhm, H.; Mahajan, S.M. (Department of Physics and Astronomy, University of Maryland, College Park, Maryland 20742). *Phys. Fluids;* **19**: No. 10, 1608-1620(Oct 1976).

Vlasov equilibrium and stability properties of a nonrelativistic nonneutral E layer are investigated for the class of thin (a very-much-less-than$R_0$) E-layer equilibria in which all electrons have the same value of the energy H and the same value of canonical angular momentum P/sub theta/, i.e., f/sub e/*(H, P/sub theta/) = ($n_0R_0/2\pi m$) $\delta$ (H+ephi-bar$_0$-m$V_0^2$/2) $\delta$ (P/sub theta/-$P_0$), where $n_0$, $R_0$, phi-bar$_0$, $V_0$, and $P_0$ are constants. No a priori restriction is made that the density is low ($\omega$/sub p/$_e^2$very-much-less-than$\omega$/sub c/$^2$), and equilibrium and stability behavior is studied for both fast ($P_0$>0) and slow ($P_0$<0) rotational equilibria. Equilibrium space-charge effects are shown to have a large (defocusing) effect on the radial thickness of the E layer when $\omega$/sub p/$_e^2\cong\omega$/sub c/$^2$. The electrostatic stability analysis includes both negative-mass (orbit variations with P/sub theta/) and diocotron (angular velocity shear) effects. The system is shown to be stable whenever the equilibrium flow is space-charge neutralized, i.e., whenever f=1, where f=n/sub i/*n/sub e/* is the fractional charge neutralization. For fvery-much-less-than1, a necessary and sufficient condition for instability is given by (l-2) a/$R_0$>f, where l is the azimuthal mode number of the perturbation. Moreover, depending on system parameters, the growth rate can be a substantial fraction of the electron plasma frequency $\omega$/sub p/$_e$. (AIP)

## PLASMA PRODUCTION

**6222 (UCID—17201) Interaction of intense heavy ion beams with various targets.** Alonso, C. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 22 Jul 1976. Contract W-7405-ENG-48. 29p. Dep. NTIS $4.00.

Recently it has been proposed that heavy ion beams could be accelerated with sufficient power and focus to generate shock heating and create hot plasmas in targets of various materials. This preliminary study addresses two aspects of this process: first, the energy deposition by the primary beam, and second, the problem of energy deposition by secondary nuclear reaction particles. For the purpose of discussion it is assumed that beams of 600 MeV/amu uranium (143 GeV total) are focussed on various targets of thickness 1-10 mm. The energy deposition within such targets by the primary and secondary particles is studied.

**6223 Target influence on TEA-$CO_2$ laser produced plasmas in air at atmospheric pressure.** Apostol, I.; Dragulinescu, D.; Grigoriu, C.; Mihailescu, I.N.; Morjan, I.; Nitoi, A.; Popescu, I.M.; Udrea, M. (Institutul de Fizica Atomica, Bucharest (Romania)); Konov, V.I. (P.N. Lebedev Physical Institute, Moscow, USSR). pp 337 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Plasma production experiments in air at atmospheric pressure using a double discharge Lamberton and Pearson type TEA-$CO_2$ laser are reported. The air breakdown in front of an aluminium target was obtained for incident laser intensities two orders of magnitude lower than the breakdown threshold intensities in air at atmospheric pressure. The radiation driven detonation wave intensity threshold was photographically estimated and found to be approximately 4.0 x $10^7$ w/cm$^2$, in a very good agreement with Raizer's theory.

**6224 $CO_2$ laser beam interaction with $CD_2$ target.** Baranov, V.Y.; Borisov, N.V.; Malyuta, D.D.; Nizjev, V.G.; Sholin, G.V. (I.V. Kurchatov Institute of Atomic Energy, Moscow, USSR). pp 338 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

In this report the measurements of some plasma parameters in $CO_2$ laser $CD_2$ target interaction at power density $4x10^{11}w.cm^{-2}$ are presented. Absorption mechanisms of laser radiation are discussed.

**6225 X-ray emission from aluminium laser-produced plasma.** Couturaud, J.C.; Faure, C.; Rocchiccioli, J.L. (Commissariat a l'Energie Atomique, Centre d'Etudes de Limeil, Villeneuve-Saint-Georges, France). pp 341 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

X-ray lines from highly stripped ions are observed and their intensity is measured. Electron temperature is deduced from relative intensities of resonance lines.

**6226 Thermally produced plasma mixtures.** Phelps, A.D.R.; Allen, J.E. (Oxford Univ. (UK). Dept. of Engineering Science). pp 128 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Measurements are reported of the plasma density in a highly ionized, thermally produced plasma containing a mixture of ions. The plasma densities in both binary and multi-component plasma mixtures are predicted for the case where the plasma potential is negative with respect to the wall potential. A floating electrostatic sheath boundary condition is assumed for the ion fluxes. There is agreement between the measured variation of the plasma density as a function of the plasma temperature and the predicted behaviour.

**6227 Ion recombination and acceleration in a laser-produced plasma.** Lovetskii, E.E.; Polyanichev, A.N.; Fetisov, V.S. (Moscow Engineering Physics Inst.). *Sov. Tech. Phys. Lett. (Engl. Transl.);* **1**: No. 5, 422-426(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 773-781(1975).

The gasdynamic equations describing the expansion into vacuum of a recombining plasma are written in terms of mass coordinates and solved numerically for Li and LiH plasmas. The spatial and energy distributions of the ions are calculated. During the expansion the peripheral ions experience a marked acceleration. The dynamics of the recombination in the expanding plasma is studied. The calculated results are compared with experiment.

**6228 Study of conical accumulation of a laser-produced plasma by x-ray spectroscopy.** Boiko, V.A.; Krokhin, O.N.; Pikuz, S.A.; Faenov, A.Ya.; Chugunov, A.Yu. *Sov. Tech. Phys. Lett. (Engl. Transl.);* **1**: No. 5, 427-429(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 782-785(1975).

The properties of the plasmas produced as laser beams are focused on flat targets and compared in conical depressions. In the case of the conical depression the plasma has a higher effective temperature, a higher density, and a longer lifetime.

**6229 Resonance interferometry on a laser-generated Li—Pb plasma.** Dreiden, G.V.; Ostrovskaya, G.V.; Pobedonostseva, N.A.; Filippov, V.N. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 1, 48(Jan 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 106-110(26 Jan 1975).

The expansion of neutrals in a laser-generated plasma from a target made of a lithium—lead alloy is investigated. To determine the density of lithium atoms a resonance interferometry method is used, which makes it possible to increase the sensitivity and the selectivity for one of the plasma components; this is done by using an interferometer wavelength which is close to the wavelength of the absorption line of the component in question. The light source for the hologram in these studies is stimulated Raman scattering of ruby laser radiation in nitrobenzene.

**6230 High-density ionization with an intense linear focus discharge.** Nyong Lee, T. (NRL, Washington, DC).. *Ann. N.Y. Acad. Sci.*; 251: 112-125(8 May 1975).

A low-pressure linear discharge (or vacuum spark) produces one or more minute (or point) plasmas. Such point plasmas emit short bursts of intense x-radiation which consists of continuum as well as line radiation arising from highly stripped high-Z atoms. Experimental results obtained with the device are described in order to improve the understanding of the phenomena. Measurements include plasma diagnostics made with fast photography, pinhole x-ray photography, and x-ray spectroscopy in the photon energy range of 6 to 350 keV. Data are shown in graphical and equation form. 17 refs.

**6231 Determination of the optical thickness of a laser-produced plasma flare from absolute spectral brightness.** Dymshitz, Yu.I. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 6, 251-252(Jun 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 554-558(26 Jun 1975).

To determine the optical thickness tau of a plasma produced by laser action on a metal surface, use is made of the relation between the spectral brightness of the radiating plasma layer b/sub lambda/ and its temperature T, the absorption coefficient K/sub lambda/, and the thickness d in the observation direction. The flare is produced by focusing in vacuum a single pulse from a neodymium laser (approximately 30 nsec at half-height) onto the surfaces of flat plates of aluminum, copper, lead, and graphite into spots 3 and 0.5 mm in diameter.

**6232 Experimental observation of shielding by a laser-produced plasma.** Dymshitz, Yu.I.; Neverov, V.G. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 6, 253-254(Jun 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 558-562(26 Jun 1975).

The transparency of a plasma produced by irradiating metals in vacuum by laser pulses has been studied, as a function of the laser flux. We record the radiation passing through a small opening in a thin metal target plate. A hole 0.12 mm in diameter is located at the center of the focal spot, the diameter of which is 3 or 0.5 mm. The axis of the hole is parallel to the laser axis and perpendicular to the target surface. The plasma produced by short laser pulses (approximately 30 nsec at half-height) overlaps the hole. The plate thicknesses are 0.15, 0.2, and 0.5 mm for aluminum, copper, and lead, respectively.

**6233 Stimulated Brillouin scattering from $CO_2$ laser produced plasma.** Offenberger, A.A.; Cervenen, M.R.; Yam, A.M.; Pasternak, A.W. (Alberta Univ., Edmonton (Canada). Dept. of Electrical Engineering). *Phys. Lett., A*; 55: No. 2, 87-89(17 Nov 1975).

Preliminary observations of stimulated backscatter from $CO_2$ laser produced plasma are reported. The scattered radiation has been spectrally resolved and the measured shift found to be consistent with that expected from ion acoustic waves. The change in wavelength shift when helium is substituted for hydrogen is in agreement with √msub(i), where msub(i)=ion mass.

**6234 Radiative transfer across expanding laser-produced plasmas. 1. Line profiles.** Irons, F.E. (Australian National Univ., Canberra. Dept. of Engineering Physics). *J. Phys., B* (*London*); 8: No. 18, 3044-3068(21 Dec 1975).

The transport of line radiation transverse to the axis of an axisymmetric expanding plasma, such as a laser-produced plasma, has been studied for line profiles in which the Doppler contr-bution from ion streaming varies from being negligible to being the dominant cause of line broadening. Emergent line profiles computed for model source functions and for profiles which are intrinsically Gaussian or Lorentzian illustrate the broad range of profiles which might be observed. The Doppler gradient can cause self-reversed profiles to appear asymmetrical, with the red peak enhanced and the blue peak suppressed, and may explain profiles of this shape previously observed in laser-produced plasmas: such profiles may provide a valuable means of measuring the transverse component of streaming velocity during the early phase of the plasma expansion. Absorption by the plasma of radiation incident from outside is also considered. Astrophysical comparisons are made and a possible source of error in the wavelength determination of lines from a laser-produced plasma is pointed out.

**6235 Soft x-ray amplification in a laser-produced plasma: a review and prognosis.** Forsyth, J.M.; Bristow, T.C.; Yaakobi, B.; Hauer, A. pp 581-629 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

Some general remarks are given on the suitability of a laser-heated plasma to produce an amplifying condition. The several mechanisms which can produce x-ray excited states in a plasma are listed with particular emphasis given to collisional processes. Examples of proposals for achieving inverted populations which rely primarily on one of each of these mechanisms are presented. (MOW)

**6236 Radiation of argon and helium supersonic plasma jets in a magnetoplasmadynamic source.** Gol'dfarb, V.M.; Il'ina, E.V.; Luk'yanov, G.A.; Nazarov, V.V.; Pavlova, N.O.; Sakhin, V.V. (A. I. Herzen Leningrad Pedagogical Institute). *High Temp.* (*USSR*) (*Engl. Transl.*); 14: No. 1, 9-14(Jan 1976).

A spectroscopic investigation is made of plasma jets from a stationary magnetohydrodynamic source streaming into a rarefied medium. The spectral-composition radiation of argon and helium jets in the visible region is investigated, and the populations of the upper atomic and ironic states in the initial gasdynamic segment of the jets are determined. The mechanisms governing the population and its dependence on the source operating conditions are shown, and data is obtained as to the effect of the composition of the ambient medium on the radiation by the plasma jets. (AIP)

**6237 Observation and simulation of effects on parylene disks irradiated at high intensities with a 1.06-μm laser.** Mead, W.C.; Haas, R.A.; Kruer, W.L.; Phillion, D.W.; Kornblum, H.N.; Lindl, J.D.; MacQuigg, D.R.; Rupert, V.C. (Lawrence Livermore Laboratory, University of California, Livermore, California 94550). *Phys. Rev. Lett.*; 37: No. 8, 489-492(23 Aug 1976).

Parylene ($C_8H_8$) disks have been irradiated with a 1.06-μm laser at fluxes of $10^{15}$—$10^{17}$ W/cm². The spatial and temporal scattered light distributions, x-ray spatial and spectral emission properties, and ion spatial and energy distributions were measured. The results, together with two-dimensional magnetohydrodynamic code simulations, imply absorption via collective processes, laser generation of suprathermal electrons, and transport inhibition consistent with the presence of megagauss-level thermoelectric magnetic fields. (AIP)

## PLASMA INSTABILITIES

*REFER ALSO TO CITATION(S) 6158, 6192, 6309, 6326*

**6238** (COO—2277-8, pp 16p, Paper III) **Streaming plasma stabilization requirements in LITE.** Fader, W.J.; Jong, R.A.; Mensing, A.E. Jun 1976.

In High beta capture and mirror confinement of laser produced plasmas.

Target plasma confinement experiments in LITE have displayed an enhanced loss of the LiH target plasma accompanied by copious bursts of rf radiation several hundred microseconds into the target decay. Although the wavelength and phase velocity of the rf activity have not been measured, comparisons with measurements in 2XII-B, PR-6 and PR-7 suggest that the drift cyclotron loss cone instability is present and accounts for the rapid loss of density. Recent advances in mirror theory predict that the drift cyclotron loss cone instability can be controlled by the introduction of a warm streaming plasma. Experiments on PR-6, PR-7, and 2XII-B confirm the stabilizing effect of the warm stream. Furthermore, experiments on 2XII-B and recent measurements in LITE showed that stable plasma decays could be obtained for plasmas in a high ambient gas density environment. In the LITE measurements, $N_2$ gas bled into the vacuum chamber raising the background pressure during the experiment, resulting in stable plasma decays as shown by the smooth density decay and absence of rf activity. On the basis of these observations, it is expected that a warm plasma stream would serve to stabilize the target plasma decay in LITE. Calculations to estimate the warm plasma current

necessary for stabilization of the LITE plasma and the development of a steady state ion source to supply the warm stream for the long duration experiments of interest in LITE are described.

**6239 Resonant instability of low frequency surface waves in magnetoactive plasma with inhomogeneous particle stream.** Cadez, V.; Vukovic, S. (Belgrade Univ. (Yugoslavia)). pp 298 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Stability characteristics of surface waves are investigated for the case of a homogeneous semi infinite, magneto-active and cold plasma with an inhomogeneous particle velocity profile. It is found that two modes of potential surface waves can exist providing certain restrictions on the magnetic field strength are met. One of these modes are oscillations with frequencies of the order of the electron plasma frequency while the other mode are low frequency waves in the ion plasma frequency region. Both types of waves become unstable at certain resonant points within the inhomogeneous region with the growth rate being generally much bigger for the waves in the high frequency domain. The increase of the magnetic field intensity tends to stabilize the instabilities but not in the same way. Namely, the high frequency unstable oscillations, which are present even in the nonmagnetic case, will completely disappear if the electron plasma frequency becomes smaller than the electron cyclotron frequency while the low frequency instability remains in although somewhat reduced.

**6240 Lower hybrid beam plasma instability.** Chang, R.P.H. (Bell Telephone Labs., Inc., Murray Hill, N.J. (USA)). pp 284 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

An experimental study is reported of the lower hybrid beam plasma instability in which an ion beam is injected into a plasma at an angle to the confining magnetic field lines. The experimental parameters were chosen such that the results are of significance to Tokomak plasmas. The experimentally measured properties of the instability are in good agreement with the theory. As the instability developed into saturation plasma heating was observed.

**6241 Absolute parametric instability in the inhomogeneous plasma near plasma resonance.** Davydova, T.A.; Shamray, K.P. (AN Ukrainskoj SSR, Kiev. Inst. Yadernykh Issledovanij). pp 320 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

In this paper the problem of absolute instability near plasma resonance is investigated on the basis of a fourth order equation without making use of the WKB approximation. The consideration may be generalized for the case of nonuniform pump wave with an extremum of intensity.

**6242 The relaxation of the parametric instability and electron heating of the magnetized plasma.** Gromov, S.N.; Pasechnik, L.L.; Semenyuk, V.F. (AN Ukrainskoj SSR, Kiev. Inst. Yadernykh Issledovanij). pp 322 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Experimental results of the investigation of the relaxation process of the parametric nondecay instability with the growth rate $\gamma$ exceeding the frequency $\omega_{sub(s)}$ of the excited oscillations and the influence of this instability on the plasma electron heating are presented.

**6243 Laboratory observations of Farley-Buneman instability.** John, P.I.; Saxena, Y.C. (Physical Research Lab., Ahmedabad (India)). pp 302 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

An experiment simulating certain characteristics of the equatorial electrojet plasma (viz. $V_{sub(en)} << \Omega_{sub(e)}$, $V_{sub(in)} >> \Omega_{sub(i)}$) is described. Instabilities are observed when electrons stream past ions with a velocity exceeding the ion acoustic speed. The observed phase velocities and frequencies agree with the results of Farley-Buneman instability theory, modified to take account of finite k(parallel). The instability spectrum and measurements of cross-field particle transport are also discussed.

**6244 Interaction of an ion beam with a target plasma created by means of a rf helix.** Massmann, P.; Hopman, H.J.; Goede, A.; Haan, P. de (F.O.M.-Instituut voor Atoom- en Molecuulfysica, Amsterdam, the Netherlands). pp 285 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Measurements are presented concerning the interaction of an ion beam with an independently created collisionless target plasma. The authors observe the excitation of a drift type instability with frequency between the ion cyclotron frequency and its 2nd harmonic. The wave propagates azimuthally across and axially along the magnetic field in the direction against the motion of the beam ions. The absolute values of the phase velocities are close to the beam velocities.

**6245 Current-driven standing waves as a source for travelling ion waves.** Popa, G.; Sato, N.; Maerk, E.; Mravlag, E.; Schrittwieser, R. (Innsbruck Univ. (Austria). Inst. fuer Theoretische Physik). pp 307 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Current-driven ion-wave instability is observed in a collisionless Q-machine plasma. The waves show standing-wave patterns between the hot plate and a grid biased to drive electron current in the plasma. Behind the grid, travelling ion waves are excited by the above instability.

**6246 High frequency drift waves in E-H accelerators.** Shishkin, G.G.; Gerasimov, V.P. (Moscow Aviation Institute, Moscow, USSR). pp 310 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The results of studying the h.f. drift instability in E-H accelerators are given. The theoretical treatment was carried out by the linear hydrodynamic approximation considering the electron and ion motion, space unhomogeneous E, H fields, the plasma density and the electron drift velocity. The instability criteria were determined on the base of the dispersion equation obtained. The detailed experimental investigation was carried out by considerable change of plasma parameters. Different experimental technique was used to determine the oscillation characteristics. It was ascertained that the h.f. drift waves existed in the region of a sharp change of the electrons' drift velocity and in the region of the negative space charge. The theory and experiment agree satisfactorily.

**6247 Conversion and stabilization of parametric instabilities by frequency shift.** Shukla, P.K.; Yu, M.Y.; Spatschek, K.H. (Bochum Univ. (F.R. Germany). Inst. fuer Theoretische Physik). pp 333 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Frequency shifts resulting from the excited turbulence associated with parametric instabilities are shown to have a stabilizing effect. The saturation energy density for the oscillating two-stream and the ion-wave decay instabilities are obtained.

**6248 Low-frequency drift oscillations in a weakly ionized plasma in a magnetic field.** Shvilkin, B.N.; Postnikov, S.A.; Skovoroda, A.A. (Moskovskij Gosudarstvennyj Univ. (USSR)). pp 312 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The article is concerned with the results of the experimental investigation of low-frequency instabilities in current-less plasma of RF discharge with inhomogeneous density in a magnetic field.

**6249 Disruptive instability in tokamaks.** Kadomtsev, B.B. (Inst. of Atomic Energy, Moscow). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 389-391(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 710-715(1975).

The internal disruptive instability recently found in the ST tokamak finds a natural explanation in terms of the onset of the m = 1 internal mode, which leads to a reclosing of the helical lines of force and to a current redistribution. A possible mechanism for the ordinary (external) disruptive instability is discussed.

**6250 Dynamic stabilization of the helical modes of a plasma column by rf fields and an automatic control system.** D'emirkhanov, R.A.; Korov, A.G.; Sidorov, V.P.; Samoilenko, Yu.I.; Gubarev, V.F.; Krivonos, Yu.G. (Physicotechnical Inst., Sukhumi, USSR). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 392-395(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 716-721(1975).

Certain aspects of the stabilization of the helical instability of a plasma column by means of an rf multipole field and an automatic control system are analyzed. A longitudinal current homogeneous over the cross section is assumed to flow through the column. The automatic control system can selectively detect and amplify each space—time harmonic of the perturbation. The conditions for complete stabilization of the helical instability are found; the necessary parameters of the rf field and of the automatic control system are also found.

**6251 Decay instability of plasma and ion-acoustic waves with steady electron-beam injection.** Matsiborko, N.G.; Onishchenko, I.N.; Oraevskii, V.N.; Sotnikov, V.I.; Shapiro, V.D.; Shevchenko, V.I. (Physicotechnical Inst., Kharkov). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 418-421(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 765-772(1975).

In a study of the mechanism for the absorption of a plasma wave excited by a beam as this wave decays into plasma and ion-acoustic waves it is shown that the evolution depends on the ratio of the growth rates for the two-stream and decay instabilities. There can be either a transfer of beam energy to the plasma wave with a subsequent energy pumping between waves or the onset of a stochastic instability which leads to a phase mixing of the beam particles and ends energy transfer from the beam. The presence of a wave with a negative energy leads to more efficient energy transfer from the beam. When damping of the low-frequency mode is taken into account, most of the energy lost by the beam remains in high-frequency waves, whose wavelength continuously increases.

**6252 Instability of dissociative attachment of a molecular-gas plasma.** Oraevskii, V.N.; Fisun, O.I.; Yurchenko, E.I. (Inst. of Electrodynamics, Kiev). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 446-448(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 814-820(1975).

The hydrodynamic stability of a plasma with negative ions in a constant electric field is studied assuming that the negative ions are formed through the dissociative attachment of electrons to molecules. Calculations are carried out for situations in which charged particles recombine at the walls and in the interior. The instability growth rates are found for both situations; the instability thresholds are determined in terms of both the relative density of negative ions and the relative density of an easily ionizable admixture.

**6253 Stabilization of a gas discharge by an rf electric field.** Rakhimova, T.V.; Rakhimov, A.T. (Moscow State Univ.). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 468-469(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 854-857(1975).

When an alternating electric field of sufficiently high frequency is imposed on a gas discharge, a prolonged state arises during which ionization of the gas is inconsequential and the discharge occurs in a recombining plasma. When the amplitudes of the constant and alternating electric fields are comparable there exists a parameter at small values of which the relative energy deposited in the gas-ionization stage can be quite small.

**6254 Formation of "bubbles" in a plasma.** Dnestrovskii, Y.N.; Zakharov, L.E.; Kostomarov, D.P.; Kukushkin, A.S.; Suzdal'tseva, L.F. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 1, 18-19(Jan 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 45-48(12 Jan 1975).

The calculation considers the model of an ideally conducting plasma with homogeneous current, perturbations of the flute type, with a pitch that coincides with the pitch of the force line are studied. It is assumed that the plasma pinch is surrounded by an ideally conducting liner GAMMA and that between them there is a vacuum gap G. A feature of this model is that the hydrodynamic equations reduce to two stationary problems with respect to the potential psi of the field in vacuum and with respect to the generalized pressure p.

**6255 Nonlinear modulational instability of plasma waves.** Al'terkop, B.A.; Volokitin, A.S.; Tarakanov, V.P. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 6, 245(Jun 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 534-537(12 Jun 1975).

It was shown earlier that as a result of the development of the modulational instability in one-dimensional plasma oscillations, the system reaches a stationary state, in which a spectrum parallel E/sub K/ parallel$^2$ approximately $k^{-2}$ obtains. In the present paper we investigate the characteristic features of the dynamics of the nonlinear stage of the instability in the supersonic regime with W/nT/sub e/ greater than m/sub e//m/sub i/ (W is the wave energy density).

**6256 Absolute Raman instability in an inhomogeneous plasma.** Cairns, R.A. (Saint Andrews Univ. (UK)). *J. Plasma Phys.*; 14: No. 2, 327-331(Oct 1975).

Stimulated Raman scattering in an inhomogeneous plasma, is examined and it is demonstrated that there may be an exponentially growing decay, which owes its existence to reflexion of the electromagnetic decay wave. Unlike absolute instabilities, which depend on simultaneous vanishing of the wavenumber mis-match and its derivative, it can occur over a wide spectrum of decay wave frequencies, and may, therefore, be of greater practical importance than those instabilities.

**6257 Effects of lithium and heavier ions on electromagnetic proton cyclotron instability.** Cuperman, S.; Gomberoff, L.; Sternlieb, A. (Tel Aviv Univ. (Israel). Dept. of Physics and Astronomy). *J. Plasma Phys.*; 14: No. 2, 195-207(Oct 1975).

The effect of lithium and heavier ions (i.e. having specific charge smaller than the proton's), on the electromagnetic cyclotron instability in warm anisotropic (bi-maxwellian) proton plasma, are analytically and numerically investigated. It is found that the occurrence of resonances for modes with ωsub(r) = Ωsub(j) (ωsub(r), real wave frequency: Ωsub(j), ion gyrofrequency), which produce a cut-off in the phase velocity, lead to the possible existance of two different situations. (i) If the proton thermal anisotropy Asub(p) is smaller than a critical value Asub(p)sup(c) (which depends on the ion specific charge), the resonance and therefore the 'stop band' occurs outside the unstable range. The maximum growth rate, as well as the instability range in k space, may increase with the relative ion concentration (etasub)j)) ion and warm proton particle densities, respectively). There is a optimum value of eta for maximum enhancement of the instability. (ii) If Asub(p) > Asub(p)sup(c), the unstable spectrum in ωsub(r) space is divided by the 'stop band' into two distinct regions. In the higher-frequency region, the maximum growth rate, as well as the width of the unstable spectrum, decrease with increasing relative ion cencentration. For eta > etasup(c), the instability is completely suppressed. In the lower-frequency region, however, the maximum growth rate and the extension in k space may increase with eta.

**6258 Relationship between the linear growth rate and the saturation amplitude for a collisional drift instability in a plasma.** Keen, B.E.; Alcock, M.W. (UKAEA Research Group, Abingdon. Culham Lab.). *Phys. Lett., A;* 55: No. 1, 25-26(3 Nov 1975).

Experiments are reported in which the relationship between the linear growth rate, $\gamma$, and the reduced saturation amplitude $A_0$ ($=n'/n_0$) is given by $\gamma=\alpha A_0^2$, for a collisional drift instability. This is predicted by a previous theory, and values of the coefficient, $\alpha$, are in reasonable agreement with this theory.

**6259 Parametric turbulence of a magnetized plasma.** Pustovalov, V.V.; Romanov, A.B.; Silin, V.P.; Tikhonchuk, V.T. *Sov. Phys. - Tech. Phys.* (*Engl. Transl.*); 21: No. 3, 265-271(Mar 1976).

The theory of weak turbulence is used to analyze the evolution of turbulent fluctuations in a homogeneous magnetized plasma. These fluctuations grow in time because of a parametric instability involving the decay of the intense pump wave into two electrostatic waves at the upper hybrid frequencies and the slow acoustic wave. At a certain point, further growth of the fluctuations is prevented by induced scattering by ions. Two types of turbulence relaxation can occur, depending on the nature of the induced scattering: an oscillatory transition of the noise to a steady turbulent state or undamped relaxation oscillations of the noise. The spectral energy density of the turbulent noise, the integral of this energy density over the spectrum, the scale times, and a quantiative description of the evolution of the noise over time and in wave vector space are found. (AIP)

**6260 Nonlinear instability of plasma pinches.** Zueva, N.M.; Solov'ev, L.S.; Morozov, A.I. (I. V. Kurchatov Institute of Atomic Energy). *JETP Lett.* (*USSR*) (*Engl. Transl.*); 23: No. 5, 256-260(5 Mar 1976).

We demonstrate the existence of a nonlinear MHD instability that leads to an appreciable modification of the internal structure of the magnetic field. (AIP)

**6261 Lower hybrid instability driven by a spiraling ion beam.** Seiler, S.; Yamada, M.; Ikezi, H. (Plasma Physics Laboratory, Princeton University, Princeton, New Jersey 08540). *Phys. Rev. Lett.*; 37: No. 11, 700-703(13 Sep 1976).

A lower-hybrid instability with ion cyclotron harmonics is observed to be resonantly driven by an ion beam injected obliquely to the confining magnetic field, in agreement with a linear, warm-plasma theory. Quasilinear velocity-space diffusion of the beam is observed. (AIP)

**6262 Influence of finite-$\beta$ effects on the lower-hybrid-drift instability in post-implosion $\theta$ pinches.** Davidson, R.C.; Gladd, N.T.; Wu, C.S.; Huba, J.D. (University of Maryland, College Park, Maryland 20742). *Phys. Rev. Lett.;* **37**: No. 12, 750-753(20 Sep 1976).

The influence of finite plasma $\beta$ on the lower-hybrid-drift instability is examined including the effects of (a) transverse electromagnetic perturbations (δBnot-equal0) and (b) resonant and nonresonant delB$_\theta$ electron-orbit modifications. For typical post-implosion $\theta$-pinch parameters, it is found that there is a critical value of local $\beta$ ($\beta$/sub c/r) such that the instability is completely stabilized ($\gamma<0$) for $\beta>\beta$/sub cr/. For example, $\beta$/sub cr/=1.6, when T/sub e//T/sub i/=1, ω/sub p//sub e/²/ω/sub c//sub e/²very-much-greater-than1, and vertical-barr/sub i/partiallnn/partialxvertical-bar=2. (AIP)

**6263 Temperature anisotropy and beam type whistler instabilities.** Hashimoto, K.; Matsumoto, H. (Department of Electrical Engineering, Kyoto University, Kyoto, Japan). *Phys. Fluids;* **19**: No. 10, 1507-1512(Oct 1976).

Whistler instabilities have been investigated for two different types, i.e., a temperature anisotropy type instability and a beam type instability. A comparison between the two types of whistler instabilities is made within the framework of linear theory. A transition from one type to the other is also discussed, which is an extension of the work on electrostatic beam and Landau instabilities performed by O'Neil and Malmberg for electromagnetic whistler instabilities. It is clarified that the essential source of the whistler instability is not a beam kinetic energy, but a temperature anisotropy even for the beam type whistler instability. (AIP)

**6264 Single-mode saturation of the bump-on-tail instability: Immobile ions.** Simon, A.; Rosenbluth, M.N. (Department of Mechanical and Aerospace Sciences and Department of Physics, University of Rochester, Rochester, New York 14627). *Phys. Fluids;* **19**: No. 10, 1567-1580(Oct 1976).

A one-dimensional collisionless electron plasma is considered with a velocity distribution of the "bump-on-tail" type. The ions are immobile and the eigenmodes are separated by finite periodic boundary conditions. The electron number density is increased above the neutral-stable value by a small fractional amount Δ. A single mode moves on to the positive slope region and grows until saturated at small amplitude by nonlinear effects. The saturated amplitude, frequency shift, and modified electron distribution function are determined in terms of Δ. The solution is shown to be stable and conserves energy and momentum. All singular functions appearing in higher harmonics are identified as generalized functions, and a correction to the class 1c mode adjoint is obtained. The solution of the "inflection-on-tail" problem is also given. (AIP)

**6265 Stabilization of drift cyclotron loss cone instability with additions of small amounts of cool plasma.** Gerver, M.J. (Electronics Research Laboratory, University of California, Berkeley, California 94720). *Phys. Fluids;* **19**: No. 10, 1581-1590(Oct 1976).

The effect of the addition of a cooler ion component on the drift cyclotron loss cone instability was investigated using the local approximation linear dispersion relation. The parameters considered were mirror ratio, density gradient, density (including finite $\beta$), ratio of cool to hot ion temperature, and type of cool component (Maxwellian or loss cone). Several different regimes of the parameter space were defined and mapped, according to the characteristics of the instability (e.g., source of free energy, critical density gradient, range of unstable wavenumbers, maximum growth rate). The most effective stabilization was found to occur for addition of a small Maxwellian cool component with density ratio (n/sub c//n/sub h/) $>3.4[(a/sub\ h//n)(dn/dx)]^{3/2}\ (R^{-1/2}-R^{-1})^{1/2}$ and with temperature ratio satisfying 1> (T/sub c//T/sub h/)$^{3/2}$(n/sub h//n/sub c/), $(R^{-1/2}-R^{-1})^{-1}>0.43$; a/sub h/ is the hot ion Larmor radius, R is the mirror ratio, n/sub c/ and n/sub h/ are the cool and hot ion densities, and T/sub c/ and T/sub h/ are the cool and hot ion temperatures. The stabilization allows a larger critical gradient, $(a/sub\ h//n)\ (dn/dx) \cong R^1/^4\ (\omega/sub\ c//sub\ i/^2/\omega/sub\ p//sub\ i/^2+m/sub\ e//m/sub\ i/)^{1/2}$, and a larger minimum unstable wavenumber $ka/sub\ h/\cong R^1/(\omega/sub\ c//sub\ i/^2/\omega/sub\ p//sub\ i/^2+m/sub\ e//m/sub\ i/)^{-1/2}$, than that with no cool component. The instability was also studied numerically for (a/sub h//n) (dn/dx) ~1, and the minimum n/sub c//n/sub h/ required for this stabilization was consistent with the density ratio used in the 2XIIB experiment at Livermore. For $\beta>0$, even smaller amount of cool plasma is needed for this stabilization. (AIP)

**6266 Nonlinear ion motion in a slow ion cyclotron mode.** Vella, M.C.; Aamodt, R.E. (University of Colorado, Boulder, Colorado 80302). *Phys. Fluids;* **19**: No. 10, 1626-1629(Oct 1976).

The nonlinear cyclotron resonance of a single ion in a coherent slow ion cyclotron wave is treated analytically, at first, for an arbitrary angle of propagation in a homogeneous magnetic field. It is found that for tokamak plasma parameters the nonlinear phase space orbits are characterized by parallel propagation, and, for this case, simple approximate expressions are obtained for the gyroradius and parallel velocity of the resonant particle. The nonlinear period is obtained, and an invariant is found which extends the theory to a system with slowly changing parameters. It also is found that heating occurs in the perpendicular direction, and cooling in the parallel direction. (AIP)

**6267 Unstable normal modes induced by magnetic shear.** Lau, Y.Y. (Department of Mathematics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139). *Phys. Fluids;* **19**: No. 10, 1644-1646(Oct 1976).

A simple mathematical model is presented to describe instabilities resulting from the transferral of energy in different regions of an inhomogeneous plasma. The normal mode solution and the stability criterion are computed. (AIP)

**6268 Warm plasma stabilization of drift-cone mode at finite beta.** Berk, H.L.; Gerver, M.J. (Lawrence Livermore Laboratory, University of California, Livermore, California 94550). *Phys. Fluids;* **19**: No. 10, 1646-1648(Oct 1976).

The fraction of warm plasma needed to stabilize the drift cyclotron loss-cone mode in a mirror machine is computed. With warm plasma present, a remnant short wavelength instability persists. (AIP)

## PLASMA WAVE PHENOMENA

*REFER ALSO TO CITATION(S) 6152, 6160, 6204, 6239, 6255*

**6269 Some phenomena in hydrogen and deuterium wall contained plasmas at pressures near the Poletaev limit.** Armstrong, R.J. (Oslo Univ. (Norway). Fysisk Institutt). pp 117 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Observations are described of wave motions in hydrogen and deuterium positive columns at low pressures. Evidence for some propagating signals and of some simple comparisons between discharges in the two isotopes is discussed. Relevence to double layer formation is suggested.

**6270 Bernstein-Greene-Kruskal wave in the beam-plasma system.** Astrelin, V.T.; Buchelnikova, N.S. (AN SSSR, Novosibirsk. Inst. Yadernoj Fiziki). pp 283 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Many authors discussed the problem of the time evolution of a cold beam-plasma instability. It was supposed that such instability can lead to the metastable state - the nonlinear Bernstein-Greene-Kruskal (BGK) wave. In this paper it is shown through numerical simulation that a cold rather low density beam-plasma system really approaches BGK-state.

**6271 Dispersion and damping of ion-acoustic waves.** Aubert, A.E.; van Dael, W. (Louvain Univ. (Belgium)). pp 293 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Previous experiments have shown a decrease in velocity of ion-acoustic waves for frequencies approaching the ion plasma frequency. The subject of the present paper is an extension of these results towards lower frequencies comparable to the ion-neutral collision frequency.

**6272 Electron drift velocities from wave amplitude asymmetry.** Babovic, V.M. (Institut za Nuklearne Nauke Boris Kidric, Belgrade (Yugoslavia)); Anicin, B.A. (Belgrade Univ. (Yugoslavia)). pp 294 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Electron waves on drifting bounded cylindrical plasmas differ in behaviour when propagated down the electron stream and against the stream. Three types of differences have been observed

experimentally: a) downstream wavenumbers are smaller than upstream wavenumbers, b) the downstream wave is less attenuated than the upstream wave, c) the downstream wave amplitude is larger than the upstream amplitude. The differences in wavenumbers led to a determination of the dragging coefficient of a drifting plasma confirming the Lorentz relation. This paper describes an attempt to determine electron drift velocities using the asymmetry in downstream and upstream wave amplitudes.

**6273 Nonlinear wave interaction in plasma waveguide systems.** Baranchuk, N.S.; Levitsky, S.M.; Karmelyuk, M.A.; Filonenko, E.G. (Kievskij Gosudarstvennyj Univ. (Ukrainian SSR)). pp 317 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Nonlinear wave interaction in bounded plasma is theoretically studied in detail only for the case when the so called decay conditions $\omega_3=\omega_1+-\omega_2$ and $k_3(\omega_3)=k_1(\omega_1)+-k_2(\omega_2)$ are satisfied and the attenuation of interacting waves is neglected. In practical waveguide systems however the second condition is usually not satisfied and the attenuation may exceed the nonlinear increment of the arising wave. In the present work, in a waveguide system containing plasma, the nonlinear interaction of some waves capable of propagating in such systems is studied. Special attention is paid to measuring the wave numbers of interacting waves and to their amplitude distribution along the system. These investigations were made for the interaction of: a) electromagnetic waves with surface plasma-waveguide and b) plasma waveguide waves with each other.

**6274 Electromagnetic waves in plasma with non-stationary magnetic field.** Barsukov, K.A.; Lizogoob, P.P. pp 295 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Neglecting transient processes the propagation of transversal electromagnetic waves in collisionless plasma along external magnetic field changed by leap in time is considered. It is shown, that after switching on the magnetic field the plane polarized wave splits into six waves, three of which propagate forward and three backward. There are two extraordinary and one ordinary wave in each group. The energy expressions for the process of the initial wave decay are received.

**6275 Microwave absorption in an overdense plasma column.** Beerwald, H.; Boehm, G.; Kampmann, B.; Schweer, B. (Bochum Univ. (F.R. Germany). Inst. fuer Experimentalphysik). pp 296 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Usually good absorption of electromagnetic waves in an inhomogeneous overdense plasma of low collision frequency can only be achieved if the density gradient is very small. In case of a steep gradient the plasma reflects almost all of the incident power and only a small fraction is really absorbed. An arrangement is described which allows virtually full power absorption even in the case of very steep density gradient and low collision frequency. The plasma diameter d is of the order of the wavelength lambda of the incident microwave.

**6276 Nonlinear coupling of ion-acoustic waves in a plasma.** Cercek, M.; Tavzes, R. (Ljubljana Univ. (Yugoslavia)). pp 318 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Investigation of the spatial evolution of nonlinearly coupled ion-acoustic waves propagating along a weakly collisional ECR plasma column in a magnetic field is reported. Two ion-acoustic waves of different frequencies $f_1$ and $f_2$ are launched by applying a sinusoidal voltage to a grid immersed in the plasma. An axially movable grid is used in determination of the damping and phase velocity of $f_1$, $f_2$ and nonlinearly generated $f_1$-$f_2$ waves. The measured spatial growth and decay are qualitatively in accordance with those obtained by nonlinear fluid theory of ion wave propagation.

**6277 Attenuation of slow electromagnetic waves on radially magnetized annular plasma columns.** Cibin, P.K. (Institut za Nuklearne Nauke Boris Kidric, Belgrade (Yugoslavia)). pp 299 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

This paper provides numerical data on the attenuation of slow electromagnetic waves propagating along a radially magnetized annular plasma column. The attenuation coefficient is derived from the determinantal equation describing both the dispersive properties and the attenuation of slow waves using the perturbation technique formulated by Anicin (1968). A determinantal equation of the problem is obtained from the requirement that non-zero solutions of Maxwell's equations in the five regions of interest should exist and satisfy the boundary conditions.

**6278 Influence of the radial magnetic field on the propagation of surface waves on annular plasma column.** Cibin, P.K. (Institut za Nuklearne Nauke Boris Kidric, Belgrade (Yugoslavia)). pp 300 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

This paper shows the influence of the radial magnetic field on the dispersion curves of surface electromagnetic waves propagating along an annular plasma column placed in this magnetic field. The plasma column is assumed to be cold, collisionless and of uniform density.

**6279 Identification of non linear Landau mechanism for electron plasma waves.** Gervais, F.; Matthieussent, G.; Olivain, J.; Quemeneur, A. (CEA Centre d'Etudes Nucleaires de Fontenay-aux-Roses, 92 (France)). pp 321 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Non linear Landau damping of a broad band spectrum of electron plasma waves has been observed. High frequency components are damped whereas frequencies lower than the spectrum grow out of background noise. The observation of the forced beat waves identifies the mechanism. Satisfactory agreement is obtained between the evolution of experimental wave components and a numerical analysis when finite radial geometry is taken into account. Conservation of the flux of plasmons is also checked.

**6280 Nonlinear wave interaction in plasmas.** Hung, N.T. (Ecole Polytechnique Federale, Lausanne (Switzerland)). pp 326 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A study is made of the nonlinear wave interaction in plasmas subject to a strong electromagnetic field of finite wavelength. It is shown that the nonlinear plasma current can be determined exactly by a non-perturbative approach. The results can be readily applied to study the wave-wave interaction in any order of the strong field.

**6281 Effective collision frequency in the presence of an ion sound wave parametrically excited in Tonks-Dattner resonance.** Ikezawa, S. (Chubu Inst. of Tech., Kasugai, Aichi (Japan)); Okuda, T. (Nagoya Univ. (Japan)). pp 324 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Effective collision frequency enhanced by an ion sound wave parametrically excited in Tonks-Dattner (T-D) resonance in a mercury vapor discharge is estimated from the Q value and the damping of a surface wave propagating along the axial direction as a test wave. It is reasonably understood on the basis of the perturbed orbit theory proposed by Weinstock et al..

**6282 Spectral density of ion acoustic plasma waves.** Ilic, D.B.; Harker, K.J.; Crawford, F.W. (Stanford Univ., Calif. (USA). Inst. for Plasma Research). pp 328 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The spectral density of ion acoustic turbulence in a low pressure positive column is measured as a function of wavenumber and frequency in two steps: first, an analog analyzer measures the cross-power spectral density, and then a digital computer performs the final spatial Fourier transform.

**6283 Effects of resonant interaction of nonlinear Langmuir waves with particles in the inhomogeneous plasma.** Istomin, J.N.; Karpman, V.I.; Shklyar, D.R. (IZMIRAN, Moscow Region, USSR). pp 288 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

This paper contains results of investigation of the damping of nonlinear monochromatic wave and resonant particle acceleration in the inhomogeneous collisionless plasma. Similar results can be derived for the whistler waves.

**6284 Microwave reflection and absorption by contaminated plasma.** Janos, W.A. (McDonnell Douglas Astronautics Co., Huntington Beach, Calif. (USA)). pp 301 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The normal radiofrequency and absorption properties of a partially ionized plasma are shown to be drastically modified when it is contaminated by weak concentrations of sufficiently small metal particles.

**6285 Second harmonic generation in the presence of Langmuir condensation.** Kamilov, K.; Khakimov, F.Kh. (Jajik State Univ., Dushanbe, USSR); Tsytovich, V.N. (P.N. Lebedev Physical Institute, Moscow, USSR). pp 325 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The influence of Langmuir condensation on the process of coalescence of two Langmuir waves into one transverse wave (generation of the second harmonic of the plasma frequency) is investigated.

**6286 New features of the dispersion relation of T.E. waves in a hot magnetized plasma for transverse propagation.** Koch, R. (Ecole Royale Militaire, Brussels (Belgium). Lab. de Physique des Plasmas). pp 303 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The author starts with the dispersion relation for transverse-electric (T.E.) waves with wavevector perpendicular to the magnetic field in a two-component Maxwellian plasma described to all orders of the temperature. Standard Newton's method furnishes the $k^2$ roots of the dispersion relation. Numerical search is helped by knowledge of various analytical expressions for the position of the roots in limiting or asymptotic cases. When ω<ωsub(ci) three series of complex roots and an isolated one are found. The isolated root is the cold plasma solution. The position of the first roots of the three series is shown. The domain of the first ion cyclotron harmonics (i.c.h.) and ωsub(LH) are determined.

**6287 The electromagnetic radiation of charged particle in a inhomogeneous plasma located in magnetic field.** Kostanyan, F.A.; Mergelian, H.S. (AN Armyanskoj SSR, Erevan). pp 272 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

In the perturbation theory approximation the problem of the radiation from charged particle moving along the spiral in the inhomogeneous plasma which electron density N=N(z) is a smooth function of position along the spiral axis is studied.

**6288 Instability of a coherent wave motion.** Krasa, J.; Pekarek, L.; Perkin, R.M. (Ceska Vedeckotechnicka Spolecnost, Prague (Czechoslovakia). Komise pro Jadernou Techniku). pp 121 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

In this contribution a simple explanation is presented of the growing irregularity of motion of an originally coherent wave using a hydrodynamic description of the wave-pattern as a whole.

**6289 'Sheath waves', collisionless damping.** Marec, J.; Leprince, P. (Paris-11 Univ., 91 - Orsay (France). Lab. de Physique des Plasmas). pp 304 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The slow surface waves excited in the ionic sheath lying between a metallic conductor and the surrounding plasma are subjected to a strong collisionless damping. A new experiment is reported where wavelengths and damping have been measured. A discussion on damping mechanism is also presented.

**6290 Observation of temporal behavior of ion wave turbulence by microwave scattering.** Mase, A.; Tsukishima, T. (Nagoya Univ. (Japan). Faculty of Engineering). pp 330 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Temporal behaviour as well as the power spectral density I(k,ω) of the electron density fluctuations of a current-driven ion wave turbulence are investigated by the microwave scattering method. For a fixed value of k, the temporal behaviour of the scattered signal is shown to be very similar to that of a band-limited Gaussian noise with the bandwidth equal to the frequency broadening Δfsub(h) of the observed I(k,ω).

**6291 Resolution of the dispersion relation of a warm magnetoplasma.** Meyer, R.L. (Nancy-1 Univ., 54 (France). Lab. de Physique des Milieux Ionises). pp 305 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A method is described for solving the exact dispersion equation D(k,ω)=0 for mod k(vector) real values and complex values of ω. A mixed numerical and graphic method, employed earlier with success for the electrostatic dispersion equation, is used.

**6292 Role of the magnetic field intensity in the process of spontaneous excitation of the ion-cyclotron oscillations in fully ionized plasmas.** Milic, B. (Belgrade Univ. (Yugoslavia)). pp 306 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

This paper investigates the region of very small non-isothermalities (T/sub e//T/sub i/ < 1.25) and determines the trend of the variation of the threshold electron drift necessary for spontaneous excitation of the longwave ion-cyclotron oscillations for nearly isothermal plasmas. Kinetic equations for one-particle distribution functions with the Landau collision integrals are used, and the condition of marginal instability is investigated in detail.

**6293 Envelope solitary wave in the beam-plasma system.** Mori, I.; Ohya, K. (Tokushima Univ. (Japan). Faculty of Engineering). pp 282 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

It is shown experimentally that the extremely large amplitude low-frequency wave localized on narrow space is generated just before the condition in which the beam—plasma discharge occurs. It seems that this wave will be made from the high-frequency waves.

**6294 Fast particles scattering on MHD plasma oscillations and plasma turbulent reactor power law spectrum.** Nikolaev, Yu.A. (Moscow Physical Engineering Institute, Moscow, USSR); Tsytovich, V.N. (P.N. Lebedev Physical Institute, Moscow, USSR). pp 331 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The theory of inhomogeneous plasma turbulent reactor (PTR) is developed. The scattering on MHD waves leads to inhomogeneous but universal power law (approximately epsilon /sup -γ/ distribution of relativistic particles generated by PTR. The γ value depends on the characteristic size of inhomogeneity. It is shown that all the possible γ values can be only between 2 and 3. This result is consistent with observational distribution of γ value in cosmic objects.

**6295 Radiation and plasma density fluctuations of beam-plasma discharge without magnetic field.** Popovitch, V.P.; Kharchenko, I.P. (AN SSSR, Moscow. Inst. Radiotekhniki i Ehlektroniki). pp 280 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

An experimental study of some characteristics of electromagnetic radiation of the new gas discharge type the beam-plasma discharge (BPD) without outer magnetic and electric field is presented.

**6296 Investigation of the 'transillumination' of the wave barrier for electron plasma waves.** Romanyuk, L.I.; Svavilniy, N.E.; Ustalov, V.V. (AN Ukrainskoj SSR, Kiev. Inst. Yadernykh Issledovanij). pp 308 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The role of different parts of the plasma electron energy spectrum in perturbation transfer through the wave barrier and the dependence of the barrier transmissivity on the potential drop on it were studied experimentally.

**6297 Quadrupole moment of localized Langmuir perturbation in an electron plasma.** Ryutova, M.P. (AN SSSR, Novosibirsk. Inst. Yadernoj Fiziki). pp 309 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

It is shown that a static electric field arises near a three-dimensional localized Langmuir perturbation and that the field is of a quadrupole character. The scale of the region in which this field exists is much larger than the dimension of the Langmuir perturbation L and is of the order of L$^3$/r/sub D/ (r/sub D/ is the Debye radius). The quadrupole moment corresponding to this 'long-range' field is found.

**6298 Ion acoustic and drift oscillations in a homogeneous ionized plasma in magnetic field.** Shvilkin, B.N.; Postnikov, S.A.; Skovoroda, A.A. (Moskovskij Gosudarstvennyj Univ. (USSR)). pp 311 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

A number of articles have reported experimental investigations of unstable oscillations in the inhomogeneous weakly ionized magnetic plasma of an RF discharge. It was concluded that these oscillations have the drift dissipative mechanism of buildup. This conclusion is confirmed in this paper by determining a dispersion equation for ion acoustic and drift oscillations.

**6299 Multiplicative generation of Langmuir solitary waves in the resonant region of nonhomogeneous plasma.** Silin, V.A. (P.N. Lebedev Physics Institute, Moscow, USSR). pp 314 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

This paper studies the spatial redistribution of the Langmuir field in the resonant region of a plasma layer, which arises when the field of the incident wave is rather small. This phenomenon corresponds qualitatively to the theory of the deformation of the plasma resonant region.

**6300 Delta-function excitation of whistlers in a cold magnetoplasma.** Vidmar, R.J.; Crawford, F.W. (Stanford Univ., Calif. (USA). Inst. for Plasma Research). pp 316 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The response to delta-function excitation of whisters in a cold, collisionless magnetoplasma has been determined via asymptotic evaluation. The results presented describe the precursor, signal arrival, and signal decay, at a distant receiver.

**6301 Mechanism of the turbulent shock formation in the rarefied plasma.** Volkov, O.V.; Yeselevich, V.G.; Kichigin, G.N.; Paperny, V.L.; Fridman, A.M. (AN SSSR, Irkutsk. Sibirskij Inst. Zemnogo Magnetizma Ionosfery i Rasprostraneniya Radiovoln). pp 290 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

The mechanism of turbulent shock formation arising in front of the magnetic barrier on flowing of a rarefied nonisothermal T/sub e/ >> T/sub i/ plasma stream onto it is investigated experimentally. It is shown that the development of ion-beam instability, driven by a part of the stream, reflected from the barrier, is the cause of turbulence. The shock width $\Delta$ is much less than the free path l and is approximately equal to ten Debye lengths. The shock position referred to the barrier with given parameters of the unperturbed plasma is conditioned by the reflected stream density.

**6302 Experimental investigation of intense ion beam-plasma interaction.** Yatsu, K.; Nozaki, Y.; Hagiwara, S.; Kojima, S. (Tokyo Univ. of Education (Japan). Dept. of Physics). pp 286 of In Phenomena in ionized gases. Vol. I. Hoelscher, J.G.A.; Schram, D.C. (eds.). Amsterdam; North-Holland Publishing Co. (1975).

From 12. international conference on phenomena in ionized gases; Eindhoven, The Netherlands (18 Aug 1975).

Ion beam-plasma interaction is studied with an intense ion beam. Instabilities are observed at frequencies just above and just below $\omega$/sub ci/ and its harmonics. When current of the ion beam is increased the frequency spectrum shows several amplitude maxima in a frequency band between two adjacent cyclotron harmonics.

**6303 Nonlinear theory for excitation of electromagnetic waves in a plasma by a magnetized relativistic electron beam.** Loladze, Ts.D.; Chogovadze, M.E. (Inst. of Physics, Tbilisi, USSR). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 399-402(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 729-735(1975).

The nonlinear interaction of a magnetized, low-density relativistic electron beam with an electromagnetic wave in a plasma is analyzed. The beam magnetization ensures that the motion of the beam electrons is one-dimensional and determines the nature of the excitation of electromagnetic waves by virtue of the orientation of the beam with respect to the wave propagation direction. The maximum amplitude of the steady-state nonlinear wave is evaluated, and the efficiency at which the beam energy is converted into electromagnetic energy is found.

**6304 Temporal echo in a semi-infinite plasma.** Pavlenko, V.N.; Repyakh, I.V. (Inst. of Physics, Kiev). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 403-405(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 736-741(1975).

In an analysis of the second-order temporal echo in a semi-infinite isotropic plasma on the basis of the model of specular reflection of electrons on the plasma boundary, an equation is derived for the nonlinear echo signal. This equation has two terms: a first term corresponding to volume waves (it is the expression for the echo field in an infinite plasma) and a second term due to the boundary. The repeated excitation of two highly damped short-wave oscillations in a plasma is accompanied by the appearance of longwave echo oscillations, which exist near the plasma boundary and whose nature is governed by the surface-wave dispersion.

**6305 Excitation of ion-acoustic waves by low-frequency electromagnetic waves propagating in a plasma-dielectric gap.** Chakraborty, B. (Jadhavpoor Univ., Calcutta). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 1, 40-41(Jan 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 89-92(26 Jan 1975).

The excitation of low-frequency ion-acoustic waves by a low-frequency electromagnetic wave at the boundary of a transparent dielectric (dielectric constant epsilon) and a plasma is studied. The distribution of the unperturbed plasma density is proportional to delta(z), where the z axis is parallel to the gradient.

**6306 Electromagnetic radiation of a charge moving along a helical path in an inhomogeneous gyrotropic plasma.** Kostanyan, F.A.; Mergelyan, O.S. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 2, 55-56(Feb 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 120-123(12 Feb 1975).

A brief theoretical analysis is given for an inhomogeneous plasma, in which the electron density N is a function of the coordinate z, and is located in an external magnetic field vector $H_0$ = e/sub z/$H_0$. The dielectric tensor of the medium can be represented by epsilon/sub ik/(z) = epsilon/sub ik,0/ + epsilon'/sub ik/(z), where epsilon'/sub ik/(z) is that part of the dielectric tensor which is determined by the variable part of N(z) = $N_0$ + N'(z). The source of the field is a point charge q moving along a helical path with velocity v along q.

**6307 Diffraction self-focusing of waves in a plasma.** Buts, V.A.; Machekhin, Yu.P. (Physicotechnical Inst., Kharkov). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 3, 135-136(Mar 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 281-285(26 Mar 1975).

When waves of large amplitude interact with a plasma, an important role is played by nonlinear effects. It is shown that under certain conditions there is a new nonlinear effect in a plasma; the threshold for this effect is much lower than for other nonlinear effect and it can modify the high-frequency pressure and its direction.

**6308 Cyclotron acceleration of electrons by microwaves in an inhomogeneous plasma.** Anisimov, A.I.; Vinogradov, N.I.; Poloskin, B.P. (Ioffe Inst. of Physics and Tech., Leningrad). *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 4, 157-158(Apr 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 331-334(12 Apr 1975).

The results of an experimental investigation of the cyclotron interactions of an electromagnetic wave with a plasma in a toroidal magnetic field are presented. The appearance of fast electrons in the electron cyclotron resonance regime ($\omega_0 = \omega$/sub He/) is studied as a function of the plasma density and the neutral pressure.

**6309 Energy transfer to the shortwave region in parametric turbulence of a magnetoactive plasma.** Kopalev, V.F.; Pustovalov, V.V.; Romanov, A.B.; Savchenko, M.A.; Tikhonchuk, V.T. *Sov. Tech. Phys. Lett. (Engl. Transl.);* 1: No. 6, 265(Jun 1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 588-591(26 Jun 1975).

When parametric instability is nonlinearly limited in an isotropic plasma, the process of induced scattering of plasma waves by the ions leads to an energy flow into the region of long waves, where there is no Landau damping and energy dissipation can be ensured, say, by decay of the plasma waves. It is shown that in a magnetoactive plasma, induced scattering of the oscillation by the ions can lead to transfer energy into the region of larger wave numbers, where the outflow of energy is ensured by Landau damping by the electrons. Parametric turbulence of a nonisothermal plasma (the electron temperature T/sub e/ exceeds the ion temperature T/sub i/) in a strong magnetic field Vector $B_0$ is considered.

**6310 Switch-shock wave structure in a magnetized partly-ionized gas.** Cramer, N.F. (Sydney Univ. (Australia). School of Physics). *J. Plasma Phys.;* 14: No. 2, 333-346(Oct 1975).

The effect of the interaction of plasma and neutral gas on the structure of switch-type shock waves propagating in a partly-ionized gas is studied. These shocks, in which the magnetic field is perpendicular to the shock front either upstream or downstream, exhibit a spiralling behaviour of the magnetic field in the shock transition region, if the Hall term is important in the Ohm's law. Observations of this behaviour for shocks propagating into a plasma with a residual neutral content of about 15% has implied an anomalously high resistivity of the plasma. We show that this can be partly explained by considering the collisions of ions with the neutral atoms in a magnetic field. We show that the extra dissipation due to the increase in resistivity goes primarily to the ions and neutrals. Thus even in the absence of viscous dissipation within each species, the heavy particles can be appreciably heated in a shock propagating into a partly-ionized gas in a magnetic field.

**6311 Surface waves at the boundary of a magneto-active plasma.** Elgin, J.N. (Imperial Coll. of Science and Technology, London (UK). Dept. of Physics). *J. Plasma Phys.;* 14: No. 2, 255-269(Oct 1975).

Dispersion relations are obtained for surface waves propagating along plasma-vacuum and plasma-plasma interfaces in a direction perpendicular to a uniform magneto-static field (that lying parallel to the interface), by setting to zero the reflexion coefficient for an incident plane wave. Complete solutions to the dispersion relations are presented for both cases and the results are displayed diagrammatically. Comparisons are made with the work of other authors.

**6312 Nonlinear decay of a large-amplitude ion-acoustic wave.** Hung, N.T. (Centre de Recherches en Physique des Plasmas, Lausanne (Switzerland)). *J. Plasma Phys.;* 14: No. 2, 347-351(Oct 1975).

This paper studies the nonlinear coupling between an ion-acoustic wave and two Alfven waves. On the basis of the MHD equations, this three-wave interaction is described within the coupled normal-mode theory. It is shown that a large-amplitude acoustic wave can decay into a pair of Alfven waves in a high-beta plasma. Calculations of the threshold condition and the maximum growth rate suggest that this decay process may occur both in the laboratory and in the ionsphere.

**6313 Stimulated backscattering of electromagnetic waves from ion—ion hybrid waves in a magnetized plasma.** Lee, K.F. (Chinese Univ. of Hong Kong, Shatin). *J. Plasma Phys.;* 14: No. 2, 245-253(Oct 1975).

In a high-density magnetized plasma composed of two ion species of different charge-to-mass ratios, electrostatic waves propagating across the magnetic field exhibit a resonance at the Buchsbaum or ion-ion hybrid frequency, in addition to the resonances at the upper and lower hybrid frequencies. In this paper, the possibility of stimulated scattering of electromagnetic waves incident normal to the magnetic field from electrostatic waves at the ion-ion hybrid frequency is investigated. Based on the cold-plasma equations, it is found that such a process is theoretically possible. Formulas for the threshold power and growth rate are obtained, which show that the threshold power is much greater, and the growth rate much less, than those of stimulated scattering from upper and lower hybrid waves.

**6314 Ion-acoustic solitons excited by a single grid.** Watanabe, S. (Paris-11 Univ., 91 - Orsay (France). Lab. de Physique des Plasmas). *J. Plasma Phys.;* 14: No. 2, 353-364(Oct 1975).

Ion-acoustic solitons are observed to form when a large-amplitude positive step voltage is applied to a single mesh grid. For the formation of the soliton, the sheath about the grid plays an important role. The number and the amplitude of the solitons are examined experimentally as a function of the nonlinear index, and are compared with theory. The observed width and the velocity of the soliton are well explained by the theory of a hot-ion fluid and Boltzmann electrons. The phase delay of two solitons by a head-on collision is also observed.

**6315 Parametric excitation of compressional Alfven waves.** Cramer, N.F.; Hewitt, R.G.L. (Sydney Univ. (Australia). School of Physics). *Phys. Lett., A;* 54: No. 6, 493-494(20 Oct 1975).

The parametric growth rate of compressional Alfven waves in a time modulated magnetic field is calculated to be three times that for the torsional Alfven wave. Such a parametric instability can be important in the magnetoacoustic resonance heating process.

**6316 Transverse electric (TE) wave propagation in a warm moving magnetoplasma with sinusoidal electron-density distribution.** Mukherjee, P.K. (Delhi Univ. (India). Dept. of Physics and Astrophysics). *Phys. Lett., A;* 54: No. 6, 490-492(20 Oct 1975).

It has been shown, using the first three moment equations in conjunction with Maxwell's equations, that the wave equation for the TE mode in a warm moving stratified magnetoplasma transforms, for an assumed sinusoidal distribution of the electron density, to the standard form of the Hill's differential equation.

**6317 Statistical theory of electromagnetic waves in turbulent plasmas.** Ben-Israel, I.; Piran, T.; Eviatar, A. (Tel Aviv Univ. (Israel)); Weinstock, J. (National Oceanic and Atmospheric Administration, Boulder, Colo. (USA)). *Astrophys. Space Sci.;* 38: No. 1, 125-155(Nov 1975).

A statistical theory, previously developed for electrostatic waves is extended to the case of electromagnetic waves in the presence of a constant magnetic field. The theory is nonlinear and contains the effects of mode-mode coupling. The extension is not straightforward as assumed previously by many authors and involves calculation of perturbed trajectories in both velocity and configuration space. A diffusion equation is derived for the average particle distribution function, the associated diffusion tensor is calculated and a nonlinear wave dispersion relation is found. All these results contain the usual quasilinear theory as the lowest order approximation.

**6318 Nonlinear wave-wave interaction between large amplitude electron Bernstein waves and ion acoustic waves.** Tsutsui, M.; Yamagishi, H.; Matsumoto, H. (Kyoto Univ. (Japan)). *Phys. Lett., A;* 55: No. 1, 31-32(3 Nov 1975).

A nonlinear wave-wave interaction between electron Bernstein and ion acoustic waves is experimentally studied in a space simulation chamber. The dispersion characteristics of decayed waves demonstrate that a large amplitude electron Bernstein wave could decay into an ion acoustic wave and possibly another mode of electrostatic cyclotron wave through nonlinear resonant mode-mode coupling.

**6319 Absorption of light by hydrogenic plasmas. 1.** Dharmawardana, M.W.C. (Paris-11 Univ., 91 - Orsay (France)). *J. Phys., B (London);* 8: No. 16, 2728-2751(11 Nov 1975).

The dispersion of light by a high-temperature hydrogenic plasma is considered from a fully quantum mechanical many-body point of view. Unlike in the usual theories, Doppler effects, Stark and pressure effects, photo-and free-free processes can all be treated within one framework of mathematical and physical assumptions. The atom-atom potential is built up ab initio from the Coulomb potentials. The method proceeds via the double-time statistical photon Green's function, the transverse dielectric function and the spectral intensity function. The mass operator of the polarization Green's function is truncated as in a random-phase approximation. Expressions are worked out for the difficult case of simultaneous Stark, pressure, Doppler and radiation reaction effects contributing to the complex refractive index. The pressure-broadening term contains contributions from the first power of the pair potential, whilst such linear contributions are absent in the Stark term. The generality of the theoretical approach and its potential computation convenience are points in its favour.

**6320 Non-convective parametric instability associated with whistler wave resonance cone.** Boswell, R.W. (European Space Research and Technology Centre, Noordwijk (Netherlands)). *Phys. Lett., A;* 55: No. 2, 93-94(17 Nov 1975).

Experimental results are presented which show that under certain conditions typical of laboratory and ionospheric plasmas, the whistler wave parametric instability is restricted in space to regions of large gradients in amplitude of the pump wave.

**6321 Lower-hybrid absorption at the ion cyclotron harmonics.** Puri, S. (Max-Planck-Institut fuer Plasmaphysik, Garching/Muenchen (F.R. Germany)). *Phys. Lett., A;* 55: No. 2, 99-100(17 Nov 1975).

In the presence of magnetic field gradients, the lower-hybrid wave can be absorbed through linear collisionless damping at the location of cyclotron or cyclotron harmonic resonances acting as singular turning points in the path of the advancing wave-front.

**6322 Waveguide modes of a warm uniaxial lossy drifting electron plasma.** Kalluri, D.; Prasad, R. (Birla Inst. of Tech., Mesra, Ranchi (India)). *Int. J. Electron.;* 39: No. 6, 637-646(Dec 1975).

In this oaoer the dispersion relation for guided waves (TM modes) in warm, uniaxial, drifting, collisional plasma is derived. The dispersion characteristics for waves in the one-dimensional case for the above plasma is thoroughly investigated. The one-dimensional case for the cold, uniaxial, drifting, lossy plasma is also studied. Critical values of collision are observed for both cases. The phase and attenuation characteristics of the 'slow', 'fast' and 'waveguide' waves are discussed and presented as graphs with the normalized collision frequency and normalized angular wave frequency as parameters. Significant results are noted.

**6323 Energy-conversion mechanisms in the formation and interaction of helicon solitons.** Bogolyubskii, I.L.; Makhan'kov, V.G. *Sov. Phys. - Tech. Phys. (Engl. Transl.);* 21: No. 3, 255-258(Mar 1976).

The formation and interaction of helicon solitons are analyzed. The governing process is the generation of acoustic waves. The possible appearance of a new channel for the turbulent dissipation of high-frequency energy associated with collisions of helicon solitons is discussed. (AIP)

**6324 Transition radiation of a modulated current in a spherical plasma sheath.** Balakirev, V.A.; Buts, V.A.; Kurilko, V.I. *Sov. Phys. - Tech. Phys. (Engl. Transl.);* 21: No. 3, 272-275(Mar 1976).

The specified-current approximation is used to analyze the excitation of an electromagnetic field by a modulated beam injected from the surface of a conducting sphere surrounded by a plasma sheath. The limiting cases of large and small sheath radii and plasma densities are studied analytically; in the intermediate case the intensity of the electromagnetic radiation is calculated numerically. (AIP)

**6325 Absorption of plasma waves in a tokamak.** Kochetkov, V.M. (A. F. Ioffe Physicotechnical Institute, Academy of Sciences of the USSR, Leningrad). *Sov. Phys. - Tech. Phys. (Engl. Transl.);* 21: No. 3, 280-283(Mar 1976).

The trajectories, collisional damping, and collisionless damping are calculated for the plasma waves which result from linear conversion of electromagnetic waves near the upper hybrid resonance for density distributions and magnetic field configurations typical of tokamaks. The damping rate for collisional damping is calculated from the electron collision frequency. In the calculation of collisionless damping, because of the wave vector projection in the direction of the magnetic field two factors must be taken into account: the finite width of the directivity pattern for the electromagnetic waves driving the plasma waves and the existence of the rotational transform in the tokamak. Several diagrams show the positions of the regions of maximum energy evolution. Curves are given for wave absorption near the upper hydrid resonance. (AIP)

**6326 rf waves in electrodynamic plasma acceleration.** Glotova, N.N.; Kurdyashev, K.P.; Ostretsov, I.N.; Porotnikov, A.A. *Sov. Phys. - Tech. Phys. (Engl. Transl.);* 21: No. 3, 288-293(Mar 1976).

In a study of the rf instability in the frequency range 0.5—10 GHz in a plasma accelerator with an external magnetic field, the conditions correpsonding to instability and to microwave generation at a level above the thermal level are determined from the intensity of the electromagnetic component of the rf field. Intense microwave generation occurs under extreme operating conditions of the plasma accelerator. The microwave intensity is 2—3 orders of magnitude above the thermal level. Microwave generation is accompanied by an increase in the ion velocity in the plasma stream while the other discharge parameters remain constant. (AIP)

**6327 Generation of slow waves by relativistic beams in plasmas.** Grishin, V.K. (Scientific-Research Institute of Nuclear Physics, Moscow). *Sov. Phys. - Tech. Phys. (Engl. Transl.);* 21: No. 3, 348-349(Mar 1976).

A theoretical discussion of the creation of slow electromagnetic waves due to the passage of relativistic electron beams in a collisional plasma is given. (AIP)

**6328 Wave excitation by modulated and unmodulated electron beams in a plasma.** Zeidlits, V.P.; Bez'yazychnyi, I.A.; Berezin, A.K. (Physicotechnical Institute, Academy of Sciences of the Ukrainian SSR, Khar'kov). *Sov. Phys. - Tech. Phys. (Engl. Transl.);* 21: No. 3, 356-358(Mar 1976).

Experimental results are given of a study of the spectral composition and stability of plasma waves excited by electron beams. (AIP)

**6329 Solitons in nonuniform media.** Chen, H.; Liu, C. (Department of Physics and Astronomy, University of Maryland, College Park, Maryland 20742). *Phys. Rev. Lett.;* 37: No. 11, 693-697(13 Sep 1976).

Nonlinear wave propagation in inhomogeneous media is studied analytically in the model of the nonlinear Schrodinger equation. Exact solutions in the form of multisolitons, accelerated in the nonuniform medium, are obtained. (AIP)

**6330 Computer simulation of nonlinear interaction between a monochromatic whistler wave and an electron beam.** Matsumoto, H.; Yasuda, Y. (Space Science Division, Ames Research Center, National Aeronautics and Space Administration, Moffett Field, California 94035). *Phys. Fluids;* 19: No. 10, 1513-1522(Oct 1976).

A computer experiment on the self-consistent nonlinear interaction between a large amplitude whistler mode wave propagating along an external magnetic field and plasma particles is described. The plasma is composed of cold electrons, cold ions, and a hot electron beam with the mean velocity around the resonance velocity of the propagating large amplitude whistler mode wave. In addition to an amplitude oscillation of the whistler mode wave, an interesting evolution of the velocity distribution function of the hot beam electrons is observed. These results are first compared with the theory by Palmadesso and Schmidt and then are explained by a simpler physical picture. The computer code for the present simulation followed nonrelativistic dynamics of 3072 electrons in a self-consistent electromagnetic field. The total energy in the system under consideration was conserved well with a maximum numerical error of 0.3%. (AIP)

**6331 Nonlinear theory of stimulated backscattering in a bounded dissipative plasma.** Fuchs, V. (Direction Sciences de base, Institut de recherche de l'Hydro-Quebec, Varennes, Quebec, Canada, JOL 2PO). *Phys. Fluids;* 19: No. 10, 1554-1560(Oct 1976).

The anomalous reflectivity, $k^2$, of a bounded plasma, dissipative for the excited electrostatic wave, is investigated. Quantitatively, the phenomenon is controlled by three characteristic lenghts: L, the length of the plasma, L/sub a/, the longitudinal absorption length, and $L_0$, the basic gain length. When the parametric decay instability is convective, $L_0$/L/sub a/equivalent$\beta$> or.=2, Tang's approximation is shown to apply. With $\alpha^2$=2LL/sub a//$L_0^3$, and $\epsilon^2$= (radiation noise/incident signal), it is found that when $\Gamma$=$\epsilon^2$ exp($\alpha^2$) approximately-less-than0.1, $k^2$ is negligible. When $\Gamma$approximately-greater-than0.1, then $k^2 \cong 1-\alpha^{-2}$ ln(1/4$\epsilon^2$). In the regime of absolute instability, $\beta$<2, with zero noise, it is found that the reflectivity in implicit form is $\kappa L/L_0 = F(\pi/2, k) + (1/2) F(\tan^{-1} A, k)$. F is the elliptic integral of the first kind, $\kappa^2 = 1-\beta^2/4$ k/sub c/², k/sub c/²=1-k², A=2B/k/sub c/(1-B²), B=$\beta$/2k/sub c/$\kappa$. As a function of $L/L_0$, the reflectivity saturates at $1-\beta^2/4$. (AIP)

**6332 Enhanced microwave scattering at the upper hybrid frequency.** Cano, R.; Fidone, I.; Mendonca, J.T.; Zanfagna, B. (Departement de la Physique du Plasma et de la Fusion Controlee, Centre d'Etudes Nucleaires, Association Euratom-CEA, 92-Fontenay-aux-Roses, France). *Phys. Fluids;* 19: No. 10, 1561-1566(Oct 1976).

The results of an experiment of wave scattering by coherent phase density fluctuations at the upper hybrid resonance are presented. Enhanced microwave scattering from small amplitude density fluctuations at 110 kHz in an argon plasma is observed. The results show that the scattered field is generated in a small region where the frequency of the incident microwave beam equals the local upper hybrid frequency. The measured angle of the direction of maximum scattered power is in agreement with the conservation of momentum in the direction of the confining magnetic field. An absolute calibration of the detection chain leads to a value of the scattered flux in good agreement with the theoretical calculation. Possible applications of the present results as a diagnostic tool for high temperature dense plasma are discussed. (AIP)

**6333 Damped nonlinear Schrodinger equation.** Nicholson, D.R.; Goldman, M.V. (Department of Astro-Geophysics, University of Colorado, Boulder, Colorado 80309). *Phys. Fluids;* **19**: No. 10, 1621-1625(Oct 1976).

High frequency electrostatic plasma oscillations described by the nonlinear Schrodinger equation in the presence of damping, collisional or Landau, are considered. At early times, Landau damping of an initial soliton profile results in a broader, but smaller amplitude soliton, while collisional damping reduces the soliton size everywhere; soliton speeds at early times are unchanged by either kind of damping. For collisional damping, soliton speeds are unchanged for all time. (AIP)

**6334 Ion acoustic waves at a plasma sheath.** Gary, S.P.; Alexeff, I.; Hsieh, S. (Physics Department, College of William and Mary, Williamsburg, Virginia 23185). *Phys. Fluids;* **19**: No. 10, 1630-1634(Oct 1976).

The propagation of ion acoustic waves toward a plasma sheath is considered, using a fluid model which allows charge separation. It is assumed that wavelengths are sufficiently short to apply the WKB approximation and that amplitudes remain sufficiently small to use the linear approximation. Under these approximations, ion acoustic waves are not reflected from a plasma sheath, and in general are somewhat damped, although they may undergo weak growth deep in the sheath. (AIP)

## THERMONUCLEAR POWER PLANTS

*REFER ALSO TO CITATION(S) 5167, 5601, 6364*

**6335** (CONF-750989—P1, pp I.1-I.16) **Overview of the US fusion program.** Kintner, E.E. (ERDA, Washington, DC). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

A brief review of worldwide energy consumption and damands is given. The relation of the fusion development program on the energy crisis is discussed in terms of cost, timetables, and research planning. Some materials requirements for fusion reactors are briefly mentioned. (MOW)

**6336** (CONF-761005—4) **Controlled thermonuclear fusion reactors.** Walstrom, P.L. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-eng-26. 5p. Dep. NTIS $3.50.

From Instrumentation Society of America meeting; Houston, Texas, United States of America (USA) (11 Oct 1976).

Controlled production of energy by fusion of light nuclei has been the goal of a large portion of the physics community since the 1950's. In order for a fusion reaction to take place, the fuel must be heated to a temperature of 100 million degrees Celsius. At this temperature, matter can exist only in the form of an almost fully ionized plasma. In order for the reaction to produce net power, the product of the density and energy confinement time must exceed a minimum value of $10^{20}$ sec $m^{-3}$, the so-called Lawson criterion. Basically, two approaches are being taken to meet this criterion: inertial confinement and magnetic confinement. Inertial confinement is the basis of the laser fusion approach; a fuel pellet is imploded by intense laser beams from all sides and ignites. Magnetic confinement devices, which exist in a variety of geometries, rely upon electromagnetic forces on the charged particles of the plasma to keep the hot plasma from expanding. Of these devices, the most encouraging results have been achieved with a class of devices known as tokamaks. Recent successes with these devices have given plasma physicists confidence that scientific feasibility will be demonstrated in the next generation of tokamaks; however, an even larger effort will be required to make fusion power commercially feasible. As a result, emphasis in the controlled thermonuclear research program is beginning to shift from plasma physics to a new branch of nuclear engineering which can be called fusion engineering, in which instrumentation and control engineers will play a major role. Among the new problem areas they will deal with are plasma diagnostics and superconducting coil instrumentation.

**6337** (LA-UR—76-1724) **Engineering and physics considerations for a linear theta-pinch hybrid reactor (LTPHR).** Krakowski, R.A.; Miller, R.L.; Hagenson, R.L. (Los Alamos Scientific Lab., N.Mex. (USA)). 1976. Contract W-7405-Eng-36. 23p. (CONF-760733—2). Dep. NTIS $3.50.

From Joint US-USSR symposium on fusion fission reactor; Livermore, California, United States of America (USA) (13 Jul 1976).

A fusion-fission hybrid reactor based on pulsed, high-$\beta$, linear theta-pinch magnetic confinement is considered. A preliminary design which incorporates key physics, engineering and economic considerations is presented. An extensive presentation of the system energy balance is made, and this energy balance is evaluated parametrically. The feasibility of end-loss reduction is addressed.

**6338 Theoretical and experimental examination of hybrid tokamak system.** Shoji, T.; Tanaka, Y.; Okuda, T. (Nagoya Univ., Japan). *Electr. Eng. Jpn.* (*Engl. Transl.*); **94**: No. 1, 40-46(Jan-Feb 1974).

Tokamak has been attracting attention because of its capability of generating a core plasma in nuclear fusion reactors. However, the conducting shell to establish plasma equilibrium in Tokamak does not suit the reactor. From this viewpoint, a hybrid system is examined without the shell. The hybrid system is referred to in the sense that the equilibrium is maintained by the magnetic field produced by the plasma current and an externally applied magnetic field. The advantages of this system are discussed.

**6339 Separatrix and forbidden zone of the straight helical heliotron magnetic field.** Uo, K. (Kyoto Univ.). *Electr. Eng. Jpn.* (*Engl. Transl.*); **94**: No. 1, 25-32(1974).

By an appropriate design of the helical windings of the helical heliotron field, the optimum size of the outermost closed magnetic surface (separatrix) inside the helical windings and the vacuum vessel can be determined. The separatrix acts as a magnetic limiter.

**6340 Status and future prospects for fusion power.** Hirsch, R.L.; Rice, W.L.R. (Atomic Energy Commission, Washington, DC). pp 42-55 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

Of the four or five fusion reactions of interest for a fusion power reactor, the deuterium-tritium (DT) reaction provides the largest energy release at the lowest temperature. It is therefore considered the most probable for first generation fusion reactors. This selection means that these reactors will operate on a thermal conversion power cycle and thereby roughly amount to a new type of "fire-box" for power plants whose character would be similar to those now in use. The characteristics of DT fusion reactors are as follows. (1) Their basic fuels are deuterium and lithium, from which tritium is bred, and these fuels can provide millions of years of energy at negligible fuel cost. (2) DT fusion reactors will be inherently safe against nuclear runaway and will have no emergency core cooling problem. (3) Environmental and safety characteristics will be very attractive. However, radioactive materials will be involved, and they will impose restrictions on plant design and operation. There are four major approaches to fusion power in the U.S. program. Three of these involve magnetic plasma confinement—tokamak, theta pinch and magnetic mirror—and one utilizes inertial confinement—laser-fusion. The status of the fusion research and development is described as will be the program plan that aims at the goal of commercial fusion power by the year 1995.

**6341 Fusion research in Japan.** Yoshikawa, S. (Tokyo Univ.). pp 56-59 of In Radiation research. Biomedical, chemical, and physical perspectives. Nygaard, O.F. (ed.). New York; Academic Press, Inc. (1975).

From 5. international radiation research congress meeting; Seattle, Washington, USA (14 Jul 1974).

See CONF-740715—.

The importance of fusion power to Japan is perhaps the greatest among nations of the world. The scarcity of other energy resources such as oil, coal, and even solar energy (as the land is small) makes it almost imperative to depend on nuclear power for her primary energy need in the future. A high population density means that the radiation hazard problems are very much greater than in other nations such as the USA. Earthquakes and unstable geological features pose a rather difficult problem in storing radioactive wastes which tend to be produced more from ordinary fission reactors, including breeders, rather than from fusion reactors, if the latter are practicable. Japan has two research groups actively engaged in fusion research, one is under the direction of Japan Atomic Energy Commission, and the other is under the direction of Ministry of Education. Work covers both reactor core plasmas and reactor technology. Japan is presently making a five-year plan to do scientific feasibility experiments in the scale comparable to the so-called D-T burner (USA) or JET (Euratom).

**6342** **Ignition by shock wave focusing and staging of thermonuclear microexplosions.** Winterberg, F. (Nevada Univ., Reno (USA). Desert Research Inst.). *Nature (London)*; **258**: No. 5535, 512-514(11 Dec 1975).

Letter to the editor.

## PHYSICS AND BLANKET ENGINEERING

*REFER ALSO TO CITATION(S) 5098, 6337*

**6343** **Recent and planned developments for nuclear heating calculational methods.** Abdou, M.A. (Argonne National Lab., IL). *Trans. Am. Nucl. Soc.*; **23**: 16-18(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

## MAGNET COILS AND FIELDS

**6344** (BNL—21563) **Aspects of safety and reliability of superconducting magnet systems for fusion power reactors.** Powell, J.; Reich, M.; Hsieh, D.; Lehner, J.; Danby, G.; Prodell, A. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 15p. (CONF-760631—9). Dep. NTIS $3.50.

From 9. symposium on fusion technology; Garmisch-Partenkirchen, German, Federal Republic of (F.R. Germany) (14 Jun 1976).

Existing superconducting (SC) systems are shown to be inadequate for predicting successful performance of fusion magnets, since they have simpler geometry, much smaller size and simpler safety systems, less complex loading conditions and cyclical variations in loads, and are not exposed to radiation. Even so, a number of mechanical and electrical failures have occurred in existing magnet systems. Using the UWMAK and various EPR SC magnet designs as starting points, a number of potential safety and reliability problems are analyzed for future Tokamak TF coil systems. The voltage withstand capability of TF coils appears to be only a few hundred volts during quenches because of release of $H_2$ from organic glues and insulators to form Penning mixtures with helium, ionization of He by gamma rays, and use of equipotential magnet structures.

**6345** (CONF-760829—3) **Stability-optimized, force-cooled, multifilamentary superconductors.** Dresner, L. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-eng-26. 4p. Dep. NTIS $3.50.

From Applied superconductivity conference; Stanford, California, United States of America (USA) (17 Aug 1976).

A numerical program has been written to calculate the temperature-time history of a uniformly pulse-heated composite superconductor cooled by supercritical helium in forced convection. The program determines the maximum sudden temperature rise from which the conductor can still recover the superconducting state. The program includes the effects of (1) current sharing, (2) the temperature variation of the specific heat of both the matrix and the superconductor, and (3) the temperature variation of the heat transfer coefficient. Using this program, one may optimize force-cooled conductors with respect to stability by simultaneously varying the copper-to-superconductor (Cu/SC) ratio and the metal-to-helium ratio. Use of stability-optimized conductors allows a given stability level to be maintained for a particular field and bath temperature and the pressure drop and pumping losses to be reduced.

**6346** (CONF-760829—4) **Investigation of stability of composite superconductors in typical coil configurations.** Miller, J.R.; Lue, J.W.; Dresner, L. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-ENG-26. 5p. Dep. NTIS $3.50.

From Applied superconductivity conference; Stanford, California, United States of America (USA) (17 Aug 1976).

The stability of various composite conductor designs in realistic coil environments has been examined. We measure the velocity of propagation or contraction of a normal region, the full recovery current, and the minimum propagating current in a coil segment. We examine the dependence of these measurements on background field, transport current, electrical insulation, cooling passage size and orientation, and proximity of other conductors. Comparison of experiment and calculation provides indirect information about local heat transfer to the helium bath and direct information about safe operating current limits for particular coil designs.

**6347** (CONF-760829—7) **Toroidal field coil system of the Oak Ridge EPR reference design.** Lue, J.W.; Luton, J.N. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-eng-26. 5p. Dep. NTIS $3.50.

From Applied superconductivity conference; Stanford, California, United States of America (USA) (17 Aug 1976).

A refined design of the toroidal field (TF) coil system for the Oak Ridge Tokamak Experimental Power Reactor (EPR) study is presented. This design is based on cable conductor cooled by force-flow supercritical helium. It uses superconducting multifilamentary $Nb_3Sn$ for a maximum design field of 11 T at the coil windings. A hybrid system which uses NbTi at low field regions is recommended. The coil structure consists of stainless steel segments welded together to form a continuous stiff honeycomb. Conductor optimization and stability analysis specifically applicable to the forced-flow cooled conductors are given.

**6348** (CONF-760829—9) **High current superconductors for tokamak toroidal field coils.** Fietz, W.A. (Oak Ridge National Lab., Tenn. (USA)). 1976. Contract W-7405-ENG-26. 5p. Dep. NTIS $3.50.

From Applied superconductivity conference; Stanford, California, United States of America (USA) (17 Aug 1976).

Conductors rated at 10,000 A for 8 T and 4.2 K are being purchased for the first large coil segment tests at ORNL. Requirements for these conductors, in addition to the high current rating, are low pulse losses, cryostatic stability, and acceptable mechanical properties. The conductors are required to have losses less than 0.4 W/m under pulsed fields of 0.5 T with a rise time of 1 sec in an ambient 8-T field. Methods of calculating these losses and techniques for verifying the performance by direct measurement are discussed. Conductors stabilized by two different cooling methods, pool boiling and forced helium flow, have been proposed. Analysis of these conductors is presented and a proposed definition and test of stability is discussed. Mechanical property requirements, tensile and compressive, are defined and test methods are discussed.

**6349** (CONF-760829—10) **Pulse loss and voltage measurements on superconducting magnets.** Shen, S.S.; Yeh, H.T. (Oak Ridge National Lab., Tenn. (USA)). Aug 1976. Contract W-7405-eng-26. 5p. Dep. NTIS $3.50.

From Applied superconductivity conference; Stanford, California, United States of America (USA) (17 Aug 1976).

This paper describes an electrical method for measuring pulse losses and compensated voltage in superconducting magnets. Test results from two pulsed solenoids are recorded and analyzed digitally by computer. Dependence of loss performance on B/sub max/ and B is studied. The effects of conductor motion and presence of normal metal on the loss performance are also discussed.

**6350** (ORNL/TM—5542) **Interaction and protection of superconducting poloidal field coils and toroidal field coils in a Tokamak Experimental Power Reactor.** Yeh, H.T.; Lue, J.W. (Oak Ridge National Lab., Tenn. (USA)). Sep 1976. Contract W-7405-ENG-26. 30p. Dep. NTIS $4.00.

The protection problems of superconducting coils in a large tokamak device are delineated. Effects of the plasma discharge on the first wall, the induced voltage, and the temperature rise during the quench of a superconducting coil, as well as the mechanical load on coils due to their mutual interaction under normal or fault conditions, are discussed. Various design choices and protection schemes are used to ensure the integrity of the coils during quench. For the Oak Ridge EPR design, a scheme of connecting symmetrically-located toroidal field coils in groups and isolating and discharging the fault coil only gives satisfactory results.

**6351** (UCRL—50016-76-2) **Mechanical Engineering Department quarterly report, April—June 1976** . Stone, R.G.; Barnett, J.M. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 30 Jun 1976. Contract W-7405-Eng-48. 36p. Dep. NTIS $4.00.

The proposed magnet system for MX will provide a minimum-absolute value B magnetic well with a 2-T central field, a vacuum mirror ratio of 2, and a mirror-to-mirror length of 3.4 m. The system will consist of a superconducting magnet in a displaced Yin-Yang configuration. Final design of the system requires analysis of the confinement field and the magnetic field and forces; development of the superconducting coil; and consideration of magnetic structure, fabrication, and installation. The MX injection system consists of the neutral-beam sources and beamlines, to build up and sustain the plasma, and the target-plasma generator, to create the initial plasma. The neutral-beam system is based on a design proved in 2XIIB, with modifications to provide increased extraction potential, ease of maintenance, and flexibility. The primary vacuum system for MX is designed to pump the molecular gas introduced by the ion sources, the neutral-beam particles that penetrate the plasma, and the mirror leakage particles. The vacuum regions are the injector-dump tanks, the end regions, and the side region around the plasma chamber. Liquid-helium-cooled

cryopanels, shielded by liquid-nitrogen-cooled chevrons, do the pumping. The MX facility will include a structure to house the MX machine and its attendant diagnostics and power supplies, a cryogenic refrigeration system, and an external vacuum pumping system. Design of the facility requires a study of structural requirements, heat load, and source gas load.

**6352** (UCRL—78463) **Multifilament $Nb_3Sn$ conductors: progress and prospects.** Deis, D.W. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 1 Aug 1976. Contract W-7405-Eng-48. 9p. (CONF-760829—13). Dep. NTIS $3.50.

From Applied superconductivity conference; Stanford, California, United States of America (USA) (17 Aug 1976).

Multifilament $Nb_3Sn$ conductors are now at the stage where several coils have been constructed and various types of material are available commercially from several suppliers. Even so, some questions remain with regard to the reliable use of this material, particularly in large-scale systems. The initial portion of this paper covers the main features of past work as they relate to the present situation. In the latter part, those areas where major uncertainties remain are described along with current projected work in these areas.

**6353 Effect of a transverse magnetic field on the parameters of a trap using a combination of the second and third harmonics of a helical field.** Akshanov, B.S.; Pyatov, V.N.; Sebko, V.P.; Tyupa, V.I. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 387-388(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 707-709(1975).

In an analysis of the effect of a transverse magnetic field on the parameters of a trap using a combination of the second and third harmonics of a helical field, an averaging method is used to calculate the parameters of a hybrid (l = 2 plus l = 3) stellarator magnetic trap in a homogeneous, external, transverse magnetic field B/sub perpendicular/. The stabilizing effect of the second harmonic of the magnetic field on the configuration is discussed.

**6354 Review of superconductivity and magnetics for fusion.** Laverick, C. (Argonne National Lab., IL). *Ann. N.Y. Acad. Sci.*; 251: 494-513(8 May 1975).

The objective of controlled thermonuclear research (CTR) the development of practical fusion reactors for production of electrical and thermal energy in large central station installations is explained. A plasma of light nuclei confined at sufficient temperature and density for a period of time long enough to release more energy by means of a controlled thermonuclear fusion process than was required to create the plasma is discussed and presented in graphical and tabular form. 10 refs.

**6355 Some comments on magnetic field reconnection.** Priest, E.R. (Saint Andrews Univ. (UK)); Cowley, S.W.H. *J. Plasma Phys.*; 14: No. 2, 271-282(Oct 1975).

Some comments are made about how to determine the speed with which magnetic flux is carried towards an X-type neutral point and reconnected. Conditions in the diffusion region near the neutral point are also investigated, with the conclusion that the streamlines and magnetic field lines cannot both be locally hyperbolic. Instead, two distinct modes may be possible. In the first, the magnetic field lines are straight, and the diffusion region does not differ greatly from that described by Parker (1963 Astrophys. J. Suppl. 8, 177). In the second, the fluid velocity components increase cubically away from the neutral point with the result that, for a given reconnection rate, the diffusion region is typically five times greater than in the Parker model.

**6356 Stability of a certain combined field.** Merches, I. (Oxford Univ. (UK). Mathematical Inst.). *Phys. Lett., A;* 55: No. 2, 98(17 Nov 1975).

A generalization of Ohm's law for infinite conductivity, leading to a force-free combined field, is given.

## FUEL SYSTEMS

*REFER ALSO TO CITATION(S) 5830, 6351*

**6357** (CONF-750989—P4, pp IV.266-IV.273) **Hydrogen isotope separation system for the Tokamak Experimental Power Reactor.** Wilkes, W.R. (Monsanto Research Corp., Miamisburg, OH). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

An isotopic separation system for processing the fuel in the Tokamak Experimental Power Reactor is described. Two cryogenic distillation columns are used in sequence to recover 80 percent of the hydrogen from a fuel mixture originally containing equal parts of deuterium and tritium with a 1 percent hydrogen impurity. The hydrogen thus removed contains less than $^1/_2$ percent tritium, which may be recovered in a separate system designed for that purpose. It is assumed that separation of the deuterium and the tritium is not required. A total tritium inventory of approximately 38,000 Ci (3.8 g) is projected.

**6358** (MATT—1274) **Potentiality of the proton—boron fuel for controlled thermonuclear fusion.** Moreau, D.C. (Princeton Univ., N.J. (USA). Plasma Physics Lab.). Aug 1976. Contract E(11-1)-3073. 26p. Dep. NTIS $4.00.

The reaction $p + {}^{11}B$ yields $3\alpha + 8.7$ MeV is evaluated as a potential fuel for a controlled thermonuclear fusion reactor.

**6359** (PIFR—863) **Electric breeding of fissile materials with low Q, non-mainline fusion drivers.** Benford, J.; Bailey, V.; Oliver, D.; DiCapua, M.; Cooper, R. (Physics International Co., San Leandro, Calif. (USA)). 1976. Contract E(04-3)-1236. 50p. Dep. NTIS $4.00.

This study evaluated two fusion concepts, an electron beam heated linear solenoid and a shock heated plasma, applied to the breeding of fissile fuels. Non-optimized but complete systems were defined and their performance and cost estimated. The e-beam system was modeled and a limited parameter survey showed that large amounts of fuel could be produced economically from linear reactors of 100 to 300 m length. Axial loss reduction (e.g., by multiple mirrors) is the crucial physics problem and the main technology development needed is high repetition operation of the e-beams. The shock heated reactor also is quite promising, although it is an earlier stage of development. The main physics uncertainty is the duration of the containment and burn phase. It also requires repetitive pulsed power supplies. The study examined production of $^{233}U$ in a molten salt with continuous processing, which minimized fission in the breeder (less than 1 percent). Addition of a $^{238}U$ fission plate increased the output and allowed much shorter or lower gain fusion sources.

**6360** (UCID—17236) **Experimental observations on long pulse intense ion diode operation.** Prono, D.S.; Clark, R.; Prestwich, K. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 7 Jul 1976. Contract W-7405-eng-48. 20p. Dep. NTIS $3.50.

An experiment in which a long pulse electron beam diode is converted to a reflexion diode is reported. The results further substantiate the model of reflex ion diode behavior as well as extend the duration of ion mode operation to greater than 500 nsec.

**6361 Scattering of ions in a dense plasma stream during charge exchange in gaseous targets.** Kartashev, K.B.; Pistunovich, V.I.; Platonov, V.V.; Ryutov, V.D.; Filimonova, E.A. *Sov. Tech. Phys. Lett.* (*Engl. Transl.*); 1: No. 5, 406-409(1975).

Translated from Pis'ma Zh. Tekh. Fiz.; 1: 742-748(1975).

An experimental study has been made of the anomalous loss which occurs during charge exchange involving a hydrogen plasma stream with a directed velocity $v$ approximately $10^8$ cm/sec and a proton current density j greater than approximately greater than A/cm$^2$ in gaseous targets. The observed loss is due to elastic scattering of protons of the plasma stream off of high-frequency oscillations excited in the beam-target system. The effect is of a threshold nature; the threshold values of the proton density in the beam, n/sub ib/, and of the plasma density in the partially ionized target, n/sub e/, corresponding to the boundary of the unstable region have been determined. Under the conditions of the present experiments, the values are n/sub ib/ approximately equal to $5 \times 10^{11}$ cm$^{-3}$ and n/sub e/ approximately equal to $1 \times 10^{13}$ cm$^{-3}$.

**6362 Fuel cycle of fusion reactors.** Kiyose, R.; Tanaka, S. (Univ. of Tokyo). *Nenryo Kyokai-shi;* 54: No. 584, 951-963(Dec 1975). (In Japanese with English abstract).

Principles and plant system designs for nuclear fusion power are described. The development status of fuel-cycle processes of fusion reactor, such as fuel injection, separation of tritium from discharged plasma gases, production and recovery of tritium in blanket, is reviewed. Finally, with regard to the safety and environment problems of fusion power reactors, production and release of radioactivity, especially that of tritium, are examined both in normal operation and during accidents. 35 refs.

## RADIATION HAZARDS

**6363** (ERDA—116(Vol.10)) **Balanced program plan. Volume 10. Fusion: analysis for biomedical and environmental research.** Hungate, F.P. (Argonne National Lab., Ill. (USA)). Jun 1976. Contract W-31-109-eng-38. 126p. Dep. NTIS $6.00.

Development of the Balanced Program Plan for analysis for biomedical and environmental research was initiated in the spring

of 1975. The goal was a redefinition of research efforts and priorities to meet ERDA's requirements for a program of health and environmental research to support the development and commercialization of energy technologies. As part of the Balanced Program planning effort the major ERDA-supported multidisciplinary laboratories were assigned responsibility for analyzing the research needs of each of nine energy technologies and describing a research program to meet these needs. The staff of the Division of Biomedical and Environmental Research was assigned the task of defining a research program addressed to each of five biomedical and environmental research categories (characterization, measurement and monitoring; physical and chemical processes and effects; health effects; ecological effects; and integrated assessment and socioeconomic processes and effects) applicable to all energy technologies. The first drafts of these documents were available for a work-shop in June 1975 at which the DBER staff and scientists from the laboratories developed a comprehensive set of program recommendations. Pacific Northwest Laboratory was assigned responsibility for defining research needs and a recommended research program for fusion and fission technologies. This report, Volume 10, presents the input for fusion.

**6364 Plant for the thermonuclear fusion of deuterium obtained from seawater.** Pedrick, A.P. British Patent 1,409,210/B/. 8 Oct 1975. 5p.

The nuclear fusion of D alone is known to require extremely high temperatures, of the order of 400 x $10^6$ °C, as compared with less than 100 x $10^6$ °C required for D-T mixture. It is believed, however, that such high temperatures might be obtained by the use of imploding high speed bullets and powerful laser pulses. The pellet implanated noses of the bullets have highly polished parabolic mirrors arranged so that as the bullets are about to make impact the laser pulses can be focussed to a point on a stream of droplets of D carried in a stream of inert gas. The D is obtained from sea water by a centrifugal or other process. The plant described represents a complete self-contained unit capable of generating its own power supplies through a turbo-generator and capable of producing electricity directly from the fusion of minute droplets carried in the stream of inert gas. The feasibility of the plant depends on whether the very great temperatures required for D-D fusion can be generated in the manner described. A full description is given of the suggested plant.

**6365 Fusion reactors and the environment.** Wrixon, A.D. (National Radiological Protection Board, Harwell (UK)). *Radiol. Prot. Bull.*; No. 14, 12-14(Jan 1976).

A summary is given of the report of a study group set up in 1971 by the Director of the UKAEA Culham Laboratory to investigate environmental and safety aspects of future commercial fusion reactors (1975, Carruthers, R., Dunster, H.J., Smith, R.D., Watson, C.J.H., and Mitchell, J.T.D., Culham Study Group Report on Fusion Reactors and the Environment, CLM-R148, HMSO, London). This report was originally issued in 1973 under limited distribution, but has only recently been made available for open circulation. Deuterium/tritium fusion is thought to be the most likely reaction to be used in the first generation of reactors. Estimates were made of the local and world-wide population hazards from the release of tritium, both under normal operating conditions and in the event of an accident. One serious type of accident would be a lithium metal fire in the blanket region of the reactor. The use of a fusible lithium salt (FLIBE), eliminating the lithium fire risk, is considered but the report concentrates on lithium metal in the blanket region. The main hazards to operating staff arise both from tritium and from neutron activation of the construction materials. Remote servicing of the reactor structure will be essential, but radioactive waste management seems less onerous than for fission reactors. Meaningful comparison of the overall hazards associated with fusion and fission power programmes is not yet possible. The study group emphasized the need for more data to aid the safety assessments, and the need for such assessments to keep pace with fusion power station design.

## POWER CONVERSION SYSTEMS

*REFER ALSO TO CITATION(S) 6362*

**6366** (UCID—17149) **Advanced-fueled fusion reactors suitable for direct energy conversion. Project note: temperature-gradient enhancement of electrical fields in insulators.** Blum, A.S.; Mancebo, L. (California Univ., Livermore (USA). Lawrence Livermore Lab.). 9 Jul 1976. Contract W-7405-Eng-48. 21p. Dep. NTIS $3.50.

Direct energy converters for use on controlled fusion reactors utilize electrodes operated at elevated voltages and temperatures. The insulating elements that position these electrodes must support large voltages and under some circumstances large thermal gradients. It is shown that even modest thermal gradients can cause major alterations of the electric-field distribution within the insulating element.

**6367** (UCRL—50039-76-1) **Advanced-fueled fusion reactors suitable for direct energy conversion. First quarterly progress report: January 1976—March 1976.** Blum, A.S. (ed.). (California Univ., Livermore (USA). Lawrence Livermore Lab.). 7 Jun 1976. Contract W-7405-ENG-48. 12p. Dep. NTIS $3.50.

By using "advanced fuels," it is possible to propose fusion reactor designs that yield a high percentage of the reaction energy in the form of energetic charged particles. Such reactors seem well suited for use with direct energy converters. This project studies the design of the direct energy converters for this application and the neutral-beam injectors which will be used for fueling and heating the reactor. A lowest mean energy for the use of the Venetian blind direct converter is discussed. Curves of the projected performance of neutral-beam injectors that extract, accelerate, and neutralize positive ions are shown.

## INERTIAL CONFINEMENT SYSTEMS

*REFER ALSO TO CITATION(S) 5553, 5555, 5556, 6176, 6177*

**6368 System of catoptric lenses.** McFarland, P.J.; Rambauske, W.R. (to Raytheon Co., Burlington, Mass. (USA)). French Patent 2,237,213/A/. 2 Jul 1973. 16p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 3 Jul 1972, USA.

Description is given of a system of catoptric lenses for combining energies provided by a certain number of sources, e.g. optical energies provided by a certain number of lasers. This system comprises sets of mirrors the reflecting surfaces of which have their focuses spaced from a common axis. The mirrors of all these sets are arranged on a common frame, which makes aperture-locking impossible. This can be applied to thermonuclear fusion.

**6369 Catoptric lens.** Rambauske, W.R. (to Raytheon Co., Burlington, Mass. (USA)). French Patent 2,237,214/A/. 2 Jul 1973. 13p. (In French).

Available from Institut National de la Propriete Industrielle, Paris (France); priority claim: 3 Jul 1972, USA.

The invention relates to a catoptric lens for combining energies transmitted by several sources such as lasers; said lens comprising mirrors, the reflective surfaces of which have their focuses spaced from a common axis of symmetry. By means of these reflecting surfaces, which are generated by the nutation of portions of quadratic conics about the axis of symmetry, it is possible to focus the energy emmited by several lasers at the focus of the exit-mirror reflecting surface. This can be applied to thermonuclear fusion.

**6370 Thermonuclear fusion by laser: American and Soviet progress.** Bamiere, C. *Rev. Def. Natl.*; 31: 127-136(May 1975). (In French).

This discussion deals with the planned stages of American and Russian projects aimed at the industrial production of energy by laser-produced thermonuclear fusion around the year 2000.

**6371 Laser fusion.** Ashby, D.E.T.F. (Atomic Energy Research Establishment, Harwell, Eng.). *J. Br. Nucl. Energy Soc.*; 14: No. 4, 311-317(Oct 1975).

Concept, orders of magnitude, high density requirements, and computer; simulation are discussed and presented in graphical and tabular form. 20 refs.

**6372 Target effect on laser breakdown plasma.** Cojocaru-Udrea, E.; Popescu, I.M.; Udrea, M.V.; Velculescu, V.G. (Institutul de Fizica Atomica, Bucharest (Romania)). *Phys. Lett., A*; 54: No. 6, 487-489(20 Oct 1975).

The influence of the evaporation of a little amount of the target material on the air breakdown is sometimes mainly due to an initial change in density. The estimations are in agreement with the performed experiments on Li, K, Sr targets with $CO_2$-TEA laser.

**6373 Self-similar spherical implosion.** Ferro Fontan, C.; Gratton, J.; Gratton, R. (Buenos Aires Univ. Nacional (Argentina). Departamento de Fisica). *Phys. Lett., A*; 55: No. 1, 35-37(3 Nov 1975).

The self-similar compression of a gas sphere is studied. The radial and time dependencies of density, temperature and velocity are obtained. A central hot region is produced. The model sets no upper limit to the compression factor. The time dependence of the required driving power is determined which agrees with known computer results for optimized implosions.

**6374 Thermal and non-thermal x-ray bremsstrahlung emission from a high-temperature plasma.** Hall, T.A. (Essex Univ., Colchester (UK)). *J. Phys., B (London);* 8: No. 18, 3089-3095(21 Dec 1975).

The results of calculations are presented which are of interest in the interpretation of x-ray temperature measurements of a laser-produced plasma. Emission from non-thermal electrons has been interpreted using a restricted class of electron distribution functions. The results of these calculations have been compared with published experimental results and the proportion and energy of the non-thermal component has been estimated.

**6375 Target compression and neutron generation.** Johnson, R.R. pp 175-189 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

Some preliminary experiments at KMS Fusion are described on laser implosion of D and D—T targets. Typical results described are fuel compressions of x20 and $10^7$ neutrons produced per laser pulse.

**6376 Overview of laser fusion.** Boyer, K. pp 1-12 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

A brief review of the possibilities of laser fusion is given. The following topics are briefly discussed: (1) interaction physics, (2) energy transport, (3) compression experimens, (4) stability, (5) laser development, and (6) D-T burn. (MOW)

**6377 Laser-induced fusion.** Brueckner, K.A. pp 13-174 of In Laser induced fusion and x-ray laser studies. Jacobs, S.F. (ed.). Reading, MA; Addison-Wesley Publishing Company, Inc. (1976).

Estimates are given of energy production compression by shocks, quasi-adiabatic compressions of spheres and shells, and problems of implosion physics.

**6378 Time-resolved X-ray spectral studies of laser-compressed targets.** Attwood, D.T.; Coleman, L.W.; Larsen, J.T.; Storm, E.K. (University of California, Lawrence Livermore Laboratory, Livermore, California 94550). *Phys. Rev. Lett.;* 37: No. 9, 499-502(30 Aug 1976).

We present temporally and spectrally resolved x-ray emission data from a laser-irradiated target. The temporal dependence is interpreted in terms of a laser heating phase, a plateau period in which the glass-shell pusher propagates radially inward, a secondary x-ray burst corresponding to stagnation of the pusher at the target center, and a rapid decay of emission in the post-compression target disassembly period. (AIP)

**6379 Implosion characteristics of deuterium—tritium pellets surrounded by high density shells.** Fraley, G.S. (Theoretical Division, Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico 87544). *Phys. Fluids;* 19: No. 10, 1495-1500(Oct 1976).

The effect of high density shells on deuterium—tritium pellets imploded by laser energy deposition or other means is investigated. Attention is centered on the inner parts of the pellet where hydrodynamics is the dominant mechanism. The implosions can then be characterized by a pressure boundary condition. Numerical solutions of the implosions are carried out over a wide range of parameters both for solid pellets and pellets with a central void. (AIP)

**6380 Study of plasma density distribution produced by irradiating a 50 $\mu$ deuterium pellet on one side with a ruby laser.** Jarboe, T.R.; Kunkel, W.B.; Lietzke, A.F. (Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720). *Phys. Fluids;* 19: No. 10, 1501-1506(Oct 1976).

Freely falling 50-$\mu$m diam deuterium pellets are irradiated on one side with a ruby laser pulse of 1 nsec rise time and beam diameter larger than 100 $\mu$m. It is found that the freely expanding plasma has an asymptotic density distribution which is shell like. The observed laser-pellet interaction time, expansion velocity, and asymptotic density distribution are found to be in good agreement with a simple model for the ablation and acceleration of the pellets. Reasonably symmetric clouds are formed provided the beam envelops the pellet and the laser pulse is long enough to "burn through" the entire target. The total number of ions produced is about $5 \times 10^{15}$. This is consistent with complete ionization of the 50-$\mu$m pellets. The plasma is given an energy on the order of 100 eV per particle when the laser intensity is $10^{12}$ W/cm$^2$. (AIP)

## COMPONENT DEVELOPMENT AND TESTING

*REFER ALSO TO CITATION(S) 5328, 5344, 5345, 5346, 5347, 5348, 5349, 5350, 5351, 5366, 5371, 5372, 5373, 5374, 5375, 5376, 5377, 5378, 5379, 5380, 5381, 5382, 5383, 5384, 5385, 5386, 5387, 5388, 5389, 5390, 5391, 5392, 5393, 5394, 5395, 5396, 5397, 5398, 5399, 5400, 5401, 5402, 5403, 5404, 5405, 5406, 5407, 5408, 5409, 5410, 5411, 5412, 5413, 5419, 5426, 5433, 5434, 5435, 5436, 5437, 5438, 5439, 5446, 5451, 5468, 5469, 5595, 6351*

**6381** (CONF-750989—P1, pp I.158-I.190) **Argonne National Laboratory dual-ion-irradiation system.** Taylor, A.; Wallace, J.; Potter, D.I.; Ryding, D.G.; Hall, B.O. (Argonne National Lab., IL). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The details of the dual 4-MV Dynamitron—2-MV Van de Graaff ion-irradiation system at Argonne National Laboratory are described. The procedures adopted to define the ion flux, fluence, and temperature of the specimen during an irradiation are briefly presented together with a standardized specimen-preparation technique for vanadium.

**6382** (CONF-750989—P1, pp I.230-I.239) **Swelling effects to be expected in materials under high transmutation gas generation rates.** Bullough, R.; Hayns, M.R. (AERE, Harwell, Eng.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The effects of high gas generation rates appropriate to the first wall of a fusion reactor on the expected swelling at the peak swelling temperature and above are discussed. The critical void size is deduced for bias driven swelling and the rate equations appropriate for the transition to gas driven swelling are outlined. Specific results of computations are presented for cold worked M316 steel for a range of temperatures and gas generation rates. Very high swelling can occur at high temperatures.

**6383** (CONF-750989—P1, pp I.395-I.416) **Modeling of synergistic effects of displaced atom and transmutant damage in fission and fusion environments.** Odette, G.R.; Langley, S.C. (Univ. of California, Santa Barbara). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

The effect of simultaneous production of displaced atoms and transmutant helium on damage microstructural evolution is studied. A range of helium generation rates which encompasses both fission and fusion reactor environments is treated. The effect of helium on the damage microstructure at the end of the nucleation stage is discussed qualitatively and treated in a growth calculation parametrically. Diffusion limited rate equations are used to model the growth at bubbles, voids and loops for various nucleation microstructures and irradiation conditions. The results of the calculations indicate that void formation and growth may be severely restricted in fusion environments at temperatures near or above the normal swelling peak. This is due to formation of a high density of small bubbles at high helium generation rates which serve as point defect sinks and enhance void vacancy emission. At lower helium generation rates characteristic of fission reactors, or at lower temperatures, the influence of transmutant helium on total void swelling is less.

**6384** (CONF-750989—P1, pp I.437-I.473) **Response of ISSEC protected first walls to DT and DD plasma neutrons.** Avci, H.I.; Kulcinski, G.L. (Univ. of Wisconsin, Madison). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. I.

It has been demonstrated that the displacement damage and gas production rates can be reduced in CTR first walls by employing passive carbon shields. Reductions in displacement damage range from 3 to 5 for 12.5 cm shield thickness and from 7 to 14 in gas production rates with the same carbon thickness. The factors of reduction are 8 to 20 for the displacements and 17 to 80 for the gas production if a 25 cm shield is used. Depending on whether the isotopes causing the radioactivity are produced as a result of fast or thermal neutron activation, the first wall radioactivity can either go up or down with the increasing carbon shield thickness. It has been found that at shutdown radioactivity in 316 SS, Al, and

Nb first walls is reduced with increasing carbon thickness while the activities in V and Ta are increased. Long term radioactivity displays the same trends in Al, 316 SS and Ta as short term radioactivity. However, the long term activity in Nb increases and that in V decreases with increasing shield thickness. It has also been found that systems operating on a D-D plasma cycle have higher displacement rates than respective D-T cycle systems. Gas production rates are slightly lower in D-D systems except for He production in 316 SS. This is due to the higher $^{58}$Ni (n,$\alpha$) cross sections for thermal neutrons.

**6385** (CONF-750989—P1, pp I.532-I.565) **Analysis of irradiation with time-dependent sources.** Schiffgens, J.O.; Graves, N.J.; Doran, D.G. (Hanford Engineering Development Lab., Richland, WA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors.

Various CTR designs call for pulsed operation with cycle lengths ranging from several seconds to about a hundred minutes, and pulse lengths ranging from nanoseconds to the neighborhood of ninety minutes. Fluctuations in temperature, stress, and damage rate resulting from pulsed reactor operation are expected to significantly affect component life. This paper describes the first phase of an analysis of effects resulting from damage rate fluctuations. Procedures for modeling cluster growth are discussed and the results of calculations of the net growth of gas containing voids during an irradiation cycle are presented. These calculations show that the pulse parameters chosen for reactors and irradiation sources can dramatically alter swelling, and most probably other irradiation effects. For example, if the irradiation pulse length is less than about 10 $\mu$ sec and the interval between pulses is greater than about ten vacancy mean lives, no void growth is possible in stainless steel regardless of temperature, dislocation density and pulse amplitude (instantaneous displacement rate) provided no voids form in displacement cascades which are large enough to survive the time between pulses.

**6386** (CONF-750989—P2) **Radiation effects and tritium technology for fusion reactors. Volume II. Proceedings of the international conference, Gatlinburg, Tennessee, October 1—3, 1975.** Watson, J.S.; Wiffen, F.W.; Bishop, J.L.; Breeden, B.K. (eds.). (Oak Ridge National Lab., Tenn. (USA)). Mar 1976. 568p. Dep. NTIS $13.50.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

Separate abstracts were prepared for each of the 31 included papers. (MOW)

**6387** (CONF-750989—P2, pp II.1-II.17) **Effect of fusion burn cycle on first wall swelling.** Choi, Y.H. (Massachusetts Inst. of Tech., Cambridge); Bement, A.L.; Russell, K.C. Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

A mathematical simulation of first wall swelling has been performed for stainless steel under a hypothetical duty cycle of 50 sec burn, 50 sec cool. In most instances steady state nucleation conditions were not established during the burn cycle, thereby necessitating the use of transient nucleation theory. The effects of transmutation helium and of surface active impurities were modelled in an approximate way. Both kinds of impurity were found to give large increases in the void nucleation rate. Suggestions for refining and extending the calculations are also given.

**6388** (CONF-750989—P2, pp II.18-II.37) **Application of damage functions to CTR component fluence limit predictions.** Simons, R.L.; Doran, D.G. (Hanford Engineering Development Lab., Richland, WA). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

Neutron sources included in this study were EBR-II, HIFR, LAMPF (Be and Cu targets), high energy deuterons incident on Be(D-Be), and 14 MeV neutrons (D-T). Several conclusions are drawn from this study: (1) High energy neutron spectra such as from D-Be and D-T reactions are the most effective of those neutron sources studied for reducing uncertainties in the fluence limit prediction for a CTR first wall spectrum. Consequently, material tests should be made in these or similar high energy spectra in order to make useful fluence limit predictions by damage functions. (2) Errors in the damage function and fluence limit prediction are minimized if all available neutron spectra are used. (3) Some neutron sources that are only slightly harder than EBR-II spectra can cause error magnification. (4) If presently available damage functions were applied to CTR spectra (assuming the damage mechanism is the same in the CTR spectra and in the spectra used to derive the damage function) the uncertainty in the fluence limit predictions would be 60 percent to greater than 100 percent at the 95 percent confidence level.

**6389** (CONF-750989—P2, pp II.38-II.63) **Influence of first wall lifetime on the cost of electricity in UWMAK type fusion reactors.** Kulcinski, G.L. (Univ. of Wisconsin, Madison); Young, J.R. Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

The effect of first wall lifetime of 0.5 to 8 years on the cost of generating electricity in the UWMAK-I and UWMAK-II reactors is investigated. It was assumed that there was little incentive to develop walls with lifetimes (determined by radiation damage) greater than 10 years because of failures due to conventional mechanisms. Based on this assumption the cost of electricity from these two reactors increased over the 10 year lifetime value by 8 to 10 percent for a wall life of 4 years, 17 to 28 percent for 2 years, 35 to 65 percent for 1 year, and 85 to 150 percent for 0.5 year lifetimes. It appears that wall lifetimes of less than 2 years are economically unattractive for these reactors and that there is a great incentive to find materials which will have in-service lifetimes between at least 4 and 10 years.

**6390** (CONF-750989—P2, pp II.72-II.83) **Irradiation creep during 4 MeV proton irradiation.** McElroy, R.J.; Hudson, J.A.; Nelson, R.S. (AERE, Harwell, Eng.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. II.

A technique has been developed for studying irradiation creep during the bombardment of metals by high energy (4 MeV) protons from a Van de Graaff accelerator. The main features of the creep testing and irradiation facility will be described and the important aspects of beam handling and specimen environmental control highlighted. Results have been obtained for thermal and irradiation creep of nickel in the temperature range 400°—600°C. In addition to an irradiation enhancement of creep, a pronounced irradiation hardening was observed. The net effect, therefore, resulted from a combination of the two processes and a logarithmic decrease in irradiation creep rate with dose was observed. The irradiation enhanced creep rate after a given time was found to increase linearly with damage rate.

**6391** (CONF-750989—P4, pp IV.1-IV.11) **Recent experimental results on solutions of deuterium in lithium.** Ihle, H.R.; Wu, C.H. (Institut fuer Chemie der Kernforschungsanlage, Jeulich, Ger.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

The existence of a number of stable molecules containing lithium and hydrogen isotopes in the saturated vapor over dilute solutions of hydrogen isotopes in lithium causes an unexpectedly high density of hydrogen isotopes in the vapor at high temperature. An evaluation of the partial pressures of the gas species Li, $Li_2$, LiD, $Li_2D$, $LiD_2$ and $D_2$ over solutions of deuterium in lithium measured in the temperature range 770 to 970°K, and extrapolation to higher temperatures, leads to the conclusion that the ratio of the atom fraction of deuterium in the gas to its atom fraction in the liquid exceeds unity above approximately 1240°K; this ratio is independent of the deuterium atom fraction in the liquid at low concentrations. Therefore the thermodynamic supposition that hydrogen isotopes can be separated from lithium by fractional distillation even at extremely low concentration exists. A direct verification of this phenomenon was made by Rayleigh distillation of Li-D solutions in the temperature range 970 to 1600°K. These measurements yield also the ratio of the deuterium atom fraction in the gas to that in the liquid and are in good agreement with the data obtained by extrapolation of partial pressures. The enrichment and depletion of deuterium in dependence on the number of theoretical plates of a distillation column at total reflux is calculated using the results.

**6392** (CONF-750989—P4, pp IV.290-IV.316) **Recovery of tritium by permeation from liquid lithium through niobium.** Weichselgartner, H.; Perchermeier, J. (Max-Planck-Institut fuer Plasmaphysik, Garching, Ger.). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Among the suggested tritium extraction processes those which deal with the permeation processes through niobium membranes are most attractive. In most cases they require large membrane areas and efficient removal of tritium on the downstream side of the membrane. To avoid these large membranes a fluidized bed assembly was set up and investigated under the aspect of T-removal. The permeating T will be bonded onto the solid phase of the fluidized bed and so the partial pressure will be reduced to a minimum. In the first stage, liquid lithium was doped with hydrogen at temperatures up to 700 C. The permeation area in this stage was formed by a niobium pot which was flushed with high-purity helium. The permeated hydrogen was measured with a highly sensitive gas-chromatograph with a He ionizations detector system. A resolution of about 10 ppb hydrogen could be attained by a special procedure. To eliminate the influence of a hydrogen background, mainly produced by the stainless steel vacuum vessel, deuterium was introduced into the liquid lithium for the second stage of the experiments. At the same time Nb-pot was replaced by a Nb-membrane in order to avoid weldings. In the investigated temperature range, the measured H and D permeation-rates allow the conclusion that it will be advantageous to keep the temperature of the molten Li relatively low. In this paper experimental data are presented and discussed.

**6393** (CONF-750989—P4, pp IV.379-IV.400) **Tritium holdup due to coatings on the first wall of fusion reactors.** Perkins, H.K.; Bottoms, W.R.; Pandolfi, T.A. (Princeton Univ., NJ). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Coatings on vacuum vessels are expected to affect the re-emission of tritium implanted by energetic bombardment from the plasma. Based on experiments with the ST tokamak and the ATC tokamak, the first plasma devices to use tritium will probably have deliberate or accidental metallic films on their interior vacuum walls. This paper presents the result of energy dispersive X-ray analysis and ion scattering spectometry on samples taken from the ST tokamak vacuum vessel; the stainless steel vessel has acquired a molybdenum-tungsten coating attributed to the evaporation of the limiter and to gettering experiments. Scanning electron micrographs reveal a cauliflower-like appearance suggesting nodular growth. Metallic coatings such as these with low hydrogen diffusion coefficients would present a barrier to the re-emission of tritium implanted in the bulk material, beneath the thin coating. Tritium holdup will depend on the mobility of hydrogen within the coating and substrate as well as the frequency and duration of plasma shots. These considerations are expected to be more important for first generation tritium machines, which could have short confinement times and a high flux of tritium bombarding the wall.

**6394** (CONF-750989—P4) **Radiation effects and tritium technology for fusion reactors. Volume IV. Proceedings of the international conference, Gatlinburg, Tennessee, October 1—3, 1975.** Watson, J.S.; Wiffen, F.W.; Bishop, J.L.; Breeden, B.K. (Oak Ridge National Lab., Tenn. (USA)). Mar 1976. 468p. Dep. NTIS $12.00.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

Separate abstracts were prepared for the 28 included papers. (MOW)

**6395** (CONF-750989—P4, pp IV.226-IV.235) **Secondary containment system for a high tritium research cryostat.** Tsugawa, R.T.; Fearon, D.; Souers, P.C.; Hickman, R.G.; Roberts, P.E. (Univ. of California, Livermore). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

A 4.2- to 300-K liquid helium cryostat has been constructed for cryogenic samples of D—T containing up to 4 x $10^{14}$ dis/s (10,000 Ci) of tritium radioactivity. The cryostat is enclosed in a secondary box, which acts as the ultimate container in case of a tritium release. Dry argon is flushed through the box, and the box atmosphere is monitored for tritium, oxygen, and water vapor. A rupture disk and abort tank protect the box atmosphere in case the sample cell breaks. If tritium breaks into the box, a powdered uranium getter trap reduces the 4 x $10^{14}$ dis/s (10,000 Ci) to 4 x $10^{9}$ dis/s (0.1 Ci) in 24 h. A backup palladium—zeolite getter system goes into operation if an overabundance of oxygen contaminates the uranium getter.

**6396** (CONF-750989—P4, pp IV.236-IV.253) **Analyses and hydrogen-isotope-transport calculations of current and future designs of the LLL rotating-target neutron source.** Steward, S.A.; Nickerson, R.; Booth, R. (Univ. of California, Livermore). Mar 1976.

From International conference on radiation effects and tritium technology for fusion reactors; Gatlinburg, Tennessee, USA (30 Sep 1975).

In Radiation effects and tritium technology for fusion reactors. Vol. IV.

Analyses of the present titanium—tritide RTNS targets are presented. These results include the hydrogen-isotope content of new and used targets, metallography, scanning electron microscopy, and hydrogen-isotope-diffusion calculations using a heat-flow finite-difference computer code. These latter calculations indicate that a combination of long target life and high neutron output is optimized when the rate of hydrogen isotope evolution from the target balances the deposition rate from the beam. Auger spectra show that carbon and oxygen species are present in the bulk and on the surface.

**6397** **Materials research for the fusion power programme.** McCracken, G.M. (Euratom-UKAEA Association for Fusion Research, Culham Laboratory, Abingdon (UK)). pp 151-156 of In Materials in power plant. Whetstone; Institution of Metallurgists (1975).

From Spring residential course on materials in power plant; Edinburgh, UK (8 Apr 1975).

The growing confidence that the plasma confinement problems of fusion power can be overcome has resulted in serious consideration now being given to other technological problems which will bave to be solved in order to build fusion reactors. The technological difficulties are in many ways similar to those of fission reactors, but there are also distinct differences. For example there is the necessity of breeding tritium, the much higher neutron energy resulting in much higher transmutation rates, the requirement for superconducting magnets, compatibility problems in the breeding blanket and the possibility of fast pulsed operation. An outline of these problems is presented with particular emphasis on the region of the breeding blanket, where the highest temperature and largest neutron fluxes will occur.

**6398** **Measurement of neutron flux from a tokamak plasma device.** Morgan, G.L.; England, A.C. (Oak Ridge National Lab., Tenn. (USA)). *Nucl. Instrum. Methods;* **129**: No. 1, 1-9(1 Nov 1975).

A system has been developed for neutron flux measurements at the ORMAK tokamak device. This system allows measurement of the time-dependence of the neutron flux during a single shot of the device as well as the energy spectrum of the neutrons. Pulse shape discrimination techniques are used with a liquid scintillation counter (NE 213) to eliminate events in the detector due to gamma rays and X-rays generated in the plasma. Results are presented for the mode in which neutral deuterium is injected into a deuterium plasma.

**6399** **Magnetically confined plasmas used as neutron sources.** Lehnert, B. (Kungliga Tekniska Hoegskolan, Stockholm (Sweden)). *Nucl. Instrum. Methods;* **129**: No. 1, 27-30(1 Nov 1975).

It may become possible to create powerful neutron sources from a number of magnetic plasma confinement schemes being investigated in fusion research. Among the one- and two-energy-component plasmas discussed so far, special attention is drawn to quasi-static systems such as the Spherator with magnetically shielded supports, as well as to rotating plasma systems such as the closed Tornado bottle and open bottles. Provided that sufficiently high ion and electron temperatures can be reached, these systems may be operated at higher plasma densities and smaller dimensions than those of mirror and Tokamak neutron sources.

**6400** **On the chemical erosion of a carbon first wall proposed for tokamak devices for controlled nuclear fusion.** Veprek, S.; Haque, M.R. (Univ. of Zurich). *Appl. Phys.;* **8**: No. 4, 303-309(Dec 1975).

Preliminary results on the chemical attack of several carbon materials by hydrogen plasma are presented and compared with the literature data on the reaction of hydrogen atoms with carbon

in an afterglow. The chemical erosion of silicon carbide and of pyrolytical graphite should not be dangerous for the ignition of fusion assuming that the reaction probability of hydrogen atoms with the particular material would not be increased due to radiation damage of the surface. 31 refs.

**6401 TRIDENT: a discreate ordinate transport code with toroidal capabilities.** Seed, T.J.; Miller, W.F. Jr.; Dudziak, D.J. (Los Alamos Scientific Lab., NM). *Trans. Am. Nucl. Soc.*; **23**: 12(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6402 D—Li neutron sources: application to the CTR Materials Program.** Saltmarsh, M.J. (Oak Ridge National Lab., TN). *Trans. Am. Nucl. Soc.*; **23**: 1(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6403 D—Li neutron sources: design features.** Grand, P. (Brookhaven National Lab., Upton, NY). *Trans. Am. Nucl. Soc.*; **23**: 1-2(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6404 Livermore neutron source program.** Davis, J.C. (Univ. of California, Livermore). *Trans. Am. Nucl. Soc.*; **23**: 2-3(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6405 Progress report on the gas-target neutron source.** Emigh, C.R.; Schneider, J.D. (Los Alamos Scientific Lab., NM). *Trans. Am. Nucl. Soc.*; **23**: 3-4(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6406 Shielding calculations for the Intense Neutron Source Facility.** Battat, M.E.; Dudziak, D.J. (Los Alamos Scientific Lab., NM). *Trans. Am. Nucl. Soc.*; **23**: 4-5(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6407 Gas-target neutron generator: plasma and gasdynamic characteristics.** deLeeuw, J.H. (Univ. of Toronto); Haasz, A.A.; Stangeby, P.C.; Robinson, J.E. *Trans. Am. Nucl. Soc.*; **23**: 5-6(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6408 Methods of charged-particle damage analysis.** Brice, D.K. (Sandia Labs., Albuquerque, NM). *Trans. Am. Nucl. Soc.*; **23**: 7(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6409 Damage function analysis for fusion reactor applications.** Doran, D.G. (Hanford Engineering Development Lab., Richland, WA); Simons, R.L.; Odette, G.R. *Trans. Am. Nucl. Soc.*; **23**: 7-8(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6410 Development and applications of damage models.** Parkin, D.M. (Los Alamos Scientific Lab., NM); Goland, A.N. *Trans. Am. Nucl. Soc.*; **23**: 8-9(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6411 Radiation damage effects of 800-MeV protons.** Coulter, C.A. (Los Alamos Scientific Lab., NM). *Trans. Am. Nucl. Soc.*; **23**: 9-10(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

**6412 Overview of methods and codes for fusion reactor nuclear analysis.** Maynard, C.W. (Univ. of Wisconsin, Madison). *Trans. Am. Nucl. Soc.*; **23**: 11-12(Jun 1976).

From Transactions of the American Nuclear Society 1976 annual meeting; Toronto, Canada (13 Jun 1976).

# GENERAL AND MISCELLANEOUS

*REFER ALSO TO CITATION(S) 5306*

## MANAGEMENT

*REFER ALSO TO CITATION(S) 6423, 6435*

## MATHEMATICS AND COMPUTERS

*REFER ALSO TO CITATION(S) 4468, 4477, 5159, 6422, 6437*

**6413 (ORNL/CSD/TM—8) ODDBALL: ORNL Developed Data Base Analyzing Lukasiewicz Language.** McGaffey, R.W.; Wooten, J.W.; Clark, D.N.; Carpenter, K.H. (Oak Ridge National Lab., Tenn. (USA)). Sep 1976. Contract W-7405-eng-26. 14p. Dep. NTIS $3.50.

The ODDBALL program uses Reverse Polish Notation and Hewlett-Packard 45 calculator commands plus additional plotting commands to manipulate vector data interactively. Many examples are given.

**6414 (UCID—17252) Computer implementation of Glimm's method.** Sod, G.A. (California Univ., Livermore (USA). Lawrence Livermore Lab.). Aug 1976. Contract W-7405-Eng-48. 30p. Dep. NTIS $4.00.

Glimm's method deals with the solution of a nonlinear hyperbolic equation. The method is rooted in the constructive proof by Glimm [Comm. Pure Appl. Math., 18, 697 (1965)] that such systems have weak solutions. The Riemann problem is examined. The iterative method of Godunov, the selection of random numbers, and the actual implementation of Glimm's method are discussed. Usage of the FORTRAN subroutine GLIMM is explained; a flow chart is provided. Graphical results are presented for three shock tube problems with 100 spatial grid points. The time for a typical problem is 10 seconds on a CDC 7600 computer. 13 figures. (RWR)

**6415 Processing systems optimization through automatic design and reorganization of program modules.** Nunamaker, J.F. Jr. (Purdue Univ., Lafayette, IN); Nylin, W.C. Jr.; Konsynski, B. Jr. pp 311-336 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

A methodology is described for the automatic design and optimization of program modules. Processes and files are grouped and reorganized in such a way as to produce an optimal design with respect to a specific target machine. Performance criteria for the optimal design is defined in terms of four components: (1) processing time, (2) transport volume, (3) core size, and (4) number and type of I/O units required.

**6416 Verification and semantic checking of APL programs.** Gerhart, S. (Carnegie-Mellon Univ., Pittsburgh). pp 337-346 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

APL is of interest in regard to program verification for two reasons: (1) Many loops may be replaced by the structured operators, resulting in easier verification of programs with arrays. (2) The partial operators introduce the complication of showing program executability. The latter reason leads to a new form of programming, called "semantic checking."

**6417 G/PL/I: extending PL/I for graph processing.** dos Santos, C.S.; Furtado, A.L. (Pontificia Univ., Rio de Janeiro). pp 347-359 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

G/PL/I extends PL/I to handle both directed and undirected graphs, which may be multigraphs. An arbitrary number of attribute—value pairs can be associated with the graph itself and with its nodes and edges. Special kinds of sets together with set-theoretic operations are provided. The implementation uses preprocessing. It consists of a supervisor and modules for several extensions to PL/I, G/PL/I being one of them.

**6418 Unified approach to the evaluation of a class of replacement algorithms.** Gelenbe, R. (Institut de Recherche d'Automatique, Rocquencourt, France). pp 361-376 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

The replacement problem arises in computer system management whenever the executable memory space available is insufficient to contain all data and code which may be accessed during the execution of an ensemble of programs. An example of this is the page replacement problem in virtual memory computers. The problem is solved by using a replacement algorithm which selects code or data items which are to be removed from executable memory whenever new items must be brought in and no more free storage space remains. An automaton-theoretic model of replacement algorithms is introduced for the class of "random, partially preloaded" replacement algorithms, which contains certain algorithms of practical and theoretical interest. An analysis of this class is provided in order to evaluate their performance, using the assumption that the references to the items to be stored are identically distributed, independent random variables. With this model it is shown that the well-known page replacement algorithms FIFO and RAND yield the same long-run page fault rates.

**6419 Syntactic pattern recognition system with learning capability.** Lee, H.C.; Fu, K.S. (Purdue Univ., West Lafayette, IN). pp 425-449 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

Stochastic syntax analysis of pictorial patterns is investigated in this study. Pictorial image identification is performed through syntax analysis and the maximum likelihood decision rule. A learning algorithm is developed through the joint application of two inference procedures. The first procedure, which relies on a man-machine interactive technique, is used to infer the generative grammar. Next, the statistical information of the images is utilized to infer the production probabilities of the grammar. Chromosome aberrations induced by radiation exposure are identified through the use of the learning algorithm and stochastic syntax analysis.

**6420 Optimization in nonhierarchic clustering.** Diday, E. (Laboratoire de Recherche en Informatique et Automatique, Rocquencourt, France). pp 451-479 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

Algorithms which are operationally efficient and which give a good partition of a finite set produce solutions that are not necessarily optimum. The main aim of this paper is a synthetic study of properties of optimality in spaces formed by partitions of a finite set. We formalize and take for a model a family of particularly efficient technique of "cluster center" type. The proposed algorithm operates on groups of points or "kernels;" these kernels adapt and evolve into interesting clusters. After developing the notion of "strong" and "weak" patterns and the computer aspects, we illustrate the different results by an artificial example and by two applications, one in mineral geology, the other in medicine to determine biological profiles.

## INFORMATION HANDLING

*REFER ALSO TO CITATION(S) 5178, 5180, 5185*

**6421 (BNL—21554) Information center as a link between basic and applied research.** Pearlstein, S. (Brookhaven National Lab., Upton, N.Y. (USA)). 1976. Contract E(30-1)-16. 15p. (CONF-760643—3). Dep. NTIS $3.50.

From 5. CODATA conference; Boulder, Colorado, United States of America (USA) (28 Jun 1976).

The National Neutron Cross Section Center (NNCSC) concerns itself with neutron physics information of a basic and applied nature. Computerized files of bibliography to the neutron physics literature, and of experimental and evaluated neutron data are maintained. The NNCSC coordinates a national effort, the Cross Section Evaluation Working Group (CSEWG) with participants from government, private, and academic institutions, to establish a computerized reference data base Evaluated Nuclear Data File (ENDF/B) for national programs. The ENDF/B is useful to basic research because it contains recommended values based on the best available measurements and is often used as reference data for normalization and analysis of experiments. For applied use the reference data are extended through nuclear model calculations or nuclear systematics to include all data of interest with standardized processing codes facilitating the use of ENDF/B in certain types of computations. Initially the main application of ENDF/B was power reactor and shield design and only neutron data were evaluated but due to the fact that for many applications both neutron and nonneutron data are required, ENDF/B has been extended in scope to include radioactive decay data and radiation spectra for the burnup and after decay heat of fission products and photon interaction data for gamma ray transport calculations. Cooperation with other centers takes place both nationally and internationally.

**6422 Information systems. Coins IV.** Tou, J.T. (ed.). New York; Plenum Press (1974). 524p. (CONF-721246—).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

Separate abstracts for 24 sections of this book appear in ERA. (SDF)

**6423 Objectives of database management.** Everest, G.C. (Univ. of Minnesota, Minneapolis). pp 1-35 of In Information systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

This paper is intended for both corporate management and the technical information specialists who are concerned or responsible for the proper management of corporate data resources. For corporate management who both use and make decisions regarding the use of database management systems it provides sufficient detail to appreciate the fact that some difficult technical problems underlie the objectives. For the technical information specialist it provides a broad view of what might be the major objectives of database management, to understand how some of his technical problems and the things that are treated lightly in today's systems really do fit into the larger picture of management. In a sense it is intended to establish a common ground of understanding between management and the information specialist—a ground from which dialogue and negotiation can spring to their mutual benefit. The assumed context of database management systems is management information systems in the business organization. This context is selected for its richness, diversity, and changeability. When management repeatedly deals with a problem area they produce a procedural manual, delegate the handling of the problem to others, and accept the challenge of dealing with new problems and new concerns, and of reaching new horizons.

**6424 Relational data base systems: a tutorial.** Date, C.J. (IBM UK Labs., Ltd., Winchester, Eng.). pp 37-54 of In Information systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

Data independence may be achieved by providing users with a simple model of the data base and a simple language for operating on that model. The advantages of relations as the basis for such a model and language are considered with respect to alternative approaches based on hierarchies and on networks.

**6425 Relational data management system.** Whitney, V.K. (General Motors Corp., Warren, MI). pp 55-66 of In Information systems. Coins IV. Tou, J.T. (ed.). New York; Plunum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

RDMS is a flexible data analysis and manipulation system based on Codd's relational operations and Child's set-theoretic operations. This presentation focuses on the application of these techniques to practical problems. Some details of our implementation on a large virtual memory computer will be given.

**6426 Data base search problem.** Palermo, F.P. (IBM Research Lab., San Jose, CA). pp 67-101 of In Information systems. Coins IV. Tou, J.T. (ed.). New York; Plunum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

The problem of constructing an efficient retrieval algorithm for responding to queries of arbitrary complexity on a relational data base is considered. A query, represented by a relation-defining expression in the relational calculus, is translated into a retrieval algorithm.

**6427 Experiment with a relational data base system in environment research.** Soop, K.; Svensson, P.; Wiktorin, L. (IBM Svenska AB, Stockholm). pp 103-117 of In Information systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

The use of computers in environmental research presents a number of problems both to the ecologist and the systems analyst. An analysis of some of these problems led in the reported project to the development of a prototype data base system, founded on the relational concept. In this paper we discuss certain characteristics of environmental data and their use, we show how these characteristics were mapped onto requirements on the software tools, and we describe how the final system attempts to meet these requirements.

**6428 Special topic data base development.** Kasarda, A.J.; Hillman, D.J. (Lehigh Univ., Bethlehem, PA). pp 119-135 of In Information systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

Two basic approaches to the development of special topic document corpora are considered. Both techniques result in a partitioning of a general heterogeneous parent corpus into distinct subsets of related documents. The first method is based on the partitioning of a document corpus with respect to the topical content explicitly defined by the documents contained in the corpus. The technique relies on a logicosyntactic analysis of the document text in order to extract topic-denoting phrases, and a weighting function based on the complexity of the logical relational environment of the extracted phrases. The second method is based on a profile-directed partitioning of the document corpus induced by an externally defined thesaurus of phrases. The topic coverage of the profile depends only on the specific requirements of the user community for whom it was defined. Any one of a number of weighting functions can be applied to the phrases and usually depends on the corpus itself. This technique is useful where text analysis is either impractical or not possible.

**6429 BOLTS: a retrieval language for tree-structured data base systems.** Hardgrave, W.T. (Univ. of Tennessee, Knoxville). pp 137-160 of In Information systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

BOLTS is a low-level retrieval language for tree-structured data base systems. BOLTS consists of several functions that provide the capability to extract nodal information in the form of sets. Those sets of nodes can then be manipulated using the BOLTS counterparts of set union, intersection, and complement. This design overcomes the problems that are inherent in the traditional approach to retrieval using Boolean operations.

**6430 Algorithm for maintaining dynamic AVL trees.** Van Doren, J.R.; Gray, J.L. (Oklahoma State Univ., Stillwater). pp 161-180 of In Information systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

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A new algorithm is presented which is suitable for the organization and maintenance of an information storage and retrieval system. The algorithm is based on a particular class of binary tree data structures known as AVL trees. The characteristics of such structures and efficient processing methods for them are given.

**6431 SPIRAL's autoindexing and searching algorithms.** West, L.E. (Sandia Labs., Albuquerque, NM). pp 181-196 of In Information systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

SPIRAL (Sandia Program for Information Retrieval) is a system for storage and retrieval of natural language text. This presentation reviews the data compression, indexing, and retrieval features of the system and gives a detailed explanation of the algorithms used in autoencoding, phrase searching, and vocabulary-pattern searching.

**6432 SEFIRE: a sequential feedback interactive retrieval system.** Tou, J.T.; Sutton, F.R. (Univ. of Florida, Gainesville). pp 197-217 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

The SEFIRE system incorporates pattern recognition principles in retrieving documents from hierarchically structured subgroups called category files, which are organized according to information contents and data relations. Such techniques reduce the overall search effort by efficiently eliminating at each level of the hierarchy those categories known to be unrelated to a user's request. The hierarchical category files coupled with efficient search strategies based upon pattern recognition principles increase the overall effectiveness of interactive retrieval. This paper discusses the design principles and presents some results from our pilot study.

**6433 Analysis of document retrieval systems using a generalized model.** Crouch, D.B. (Univ. of Florida, Gainesville). pp 219-237 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

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Several document retrieval systems are analyzed in relation to their relevance to a generalized document retrieval system and in terms of their purposes, strong points, and inadequacies. The generalized model represents a flexible, comprehensive, modular structure of a retrieval system, as opposed to previous models, which generally emphasize only a specific aspect of the retrieval problem.

**6434 Information systems for urban problem solvers.** Kochen, M. (Univ. of Michigan, Ann Arbor). pp 239-261 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

Information systems are classified according to their role in problem solving. A new conceptualization of problem solving makes more precise the distinction between well-defined problems, which we try to solve, and ill-structured problems, with which we try to cope. For information systems to help with well-defined problems an analog to Shannon's coding theorem is suggested. Eleven principles for the design of information systems to help with ill-structured problems are formulated.

**6435 EMISARI: a management information system designed to aid and involve people.** Renner, R.L. (Mathematics and Computation Lab., Washington, D.C.); Bechtold, R.M.; Clark, C.W.; Goldstein, N.H.; Marbray, D.O.; Wynn, R.L. pp 263-289 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

The EMISARI System described in the paper represents a major departure from conventional MIS design. It is oriented not toward data per se, but rather toward activities of the people who

generate and use the data. Thus it provides not merely for reporting up the chain of command but also for dissemination of policy guidance and reference material down the chain, and for lateral communication among all users. It places a premium upon flexibility, to permit rapid system modifications in response to changes in user functions and needs, and it offers a greatly simplified operation, to avoid any necessity for extensive user training or complex operation manuals. The overall approach may be viewed as a greatly modernized version of the classic telephone party line, using a computer to organize, selectively sort, and store-and-forward a constant flow of statistics, messages, estimates, reference materials, guidelines, notices, and other informational accoutrements of a modern management operation.

**6436 Transferability and translation of programs and data.** Sibley, E.H.; Merten, A.G. (Univ. of Michigan, Ann Arbor). pp 291-309 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

To transfer information systems from one computer to another, it is necessary either that the source and target systems have been constructed to meet some strict standardization specifications, or that there is a simulator or equivalent facility to translate these programs and data between systems. Some special language translators are currently available. These translate between a predefined pair of languages on the same hardware system, and/or between languages on different hardware systems. Generalized data translators are currently being developed. These would allow data files to be translated from one hardware system to another. This paper reviews these parallel efforts and discusses the components of the general translation processor necessary to translate an information system from one machine to another. A parallelism is developed between the relationship of higher-level to machine language, and the relationship of information structures to storage structures.

**6437 Quantitative timing analysis and verification for file organization modeling.** Lum, V.Y.; Senko, M.E.; Ling, H.; Barlow, J.H. (IBM San Jose Research Lab., CA). pp 377-386 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

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This paper presents the techniques used to derive the timing equations in the file organization evaluation model FOREM. To evaluate the effectiveness of these techniques, which in general use only simple mathematics, the results of the model runs were compared with those obtained by actual computer runs using the 360/50. The average error for the most complex access method tested is well under 10 percent. The discrepancies, in general, are caused by the difference between the file layouts in the model and the computer runs. A brief description of the model and short discussion of the difficulties in applying this technique are included.

**6438 Mathematical model for computer-assisted document creation.** Oren, S.S. (Xerox Corp., Palo Alto, CA). pp 387-401 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

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This model describes the preparation of a typed document on a terminal, where text segments are either retrieved from a file or typed directly to minimize elapsed time. The model is formulated as a dynamic programming problem whose asymptotic solution provides a mathematical expression for the cost per unit length of a document in terms of the systems parameters.

**6439 Representing geographic information for efficient computer search.** Merrill, R.D.; Tannenbaum, M. (Lockheed Palo Alto Research Lab., CA). pp 403-424 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

Computer-based modeling of related natural and cultural processes for a large geographic area requires an information system which accurately represents the process parameters in a readily accessible form. This paper describes the representational techniques used in an experimental system applied to the study of one such process: microwave radiation characteristics of terrain. It is shown that with these techniques depicting terrain coverage, elevation, and slope parameters, data can be retrieved easily according to physical properties and geographic locations. The representations also provide a means for efficiently analyzing spatial relationships such as adjacency and inclusion of features. Typical encoding and retrieval times are indicated.

**6440 Nonparametric learning using contextual information.** Shimura, M. (Osaka Univ.). pp 481-493 of In Information Systems. Coins IV. Tou, J.T. (ed.). New York; Plenum Press (1974).

From 4. international symposium on computer and information sciences; Miami Beach, Florida, United States of America (USA) (14 Dec 1972).

See CONF-721246—.

A multicategory pattern classifying machine which uses contextual information is developed. In the machine proposed here recognition is based on the information of succeeding patterns as well as the features of the given pattern. It is believed that the ability to recognize is substantially improved by using contextual information, as suggested by Raviv and by Edwards and Chambers. The machine consists of piecewise linear weighting devices and maximum selectors. The learning is performed by adjusting N weighting vectors and N x N additive weighting coefficients. In this paper we show the convergence proof of the learning algorithm and present some results of computer simulations on hand-printed letters. The performance of the machine compared favorably with that of other methods.

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The title may be supplemented with additional words, or a phrase, if it appears additional information would be helpful. In cases for which the title contains little or no information related to the subject entry, it may be replaced entirely by the supplementary information. A qualifier is not always required, and in such cases the title will follow the unqualified subject descriptor.

The descriptors selected for use as subject terms are generally the names of specific materials, things, or processes. To the extent possible, a qualifier is selected to describe the properties of, or processses applied to, the subject term.

Index entries are selected to indicate the important ideas and concepts presented in a document, rather than words that may appear in the text. Within the available thesaurus terms, the most probable or logical place to look for typical information is selected. "See references" are included to guide users from synonymous terms or phrases to the descriptor selected as a subject heading for the concept. (e.g. Pipeline Quality Gas see HIGH BTU GAS). "See also references" are used to indicate where to find references to subject concepts that are narrower, broader, or related to a particular subject heading. To complete an exhaustive search of a given subject, all such headings should be reviewed.

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| 2084 | 2:5710 | Dep. NTIS, $3.50 |
| BNWL-B-430(Suppl.1) | 2:5445 | Dep. NTIS, $3.50 |
| BNWL-SA-5528 | 2:5653 | Dep. NTIS, $3.50 |
| 5644 | 2:5734 | Dep. NTIS, $3.50 |
| 5653 | 2:5654 | Dep. NTIS, $3.50 |
| 5654 | 2:5663 | Dep. NTIS, $3.50 |
| 5669 | 2:5655 | Dep. NTIS, $3.50 |
| BNWL-tr-183 | 2:5486 | Dep. NTIS, $3.50 |
| 188 | 2:5417 | Dep. NTIS, $4.00 |
| 203 | 2:4590 | Dep. NTIS, $4.00 |
| CEND-374 | 2:4888 | *See* COO-2426-50 |
| CENPD-207 | 2:4779 | Combustion Engineering, Inc., Windsor, CT |
| 229 | 2:5086 | Combustion Engineering, Inc., Windsor, CT |
| CERC-TM-53 | 2:5699 | *See* AD-A-014168 |
| CERL-TR-C-19 | 2:5626 | *See* AD-A-012729 |
| 28(Vol.4A) | 2:5158 | *See* AD-A-011227 |
| 28(Vol.4C) | 2:5159 | *See* AD-A-011231 |
| CERL-TR-E-57 | 2:5685 | *See* AD-A-012109 |
| CH-3193-3 | 2:5615 | Dep. NTIS, $3.50 |
| COM-74-11089/AS | 2:5759 | NTIS, $5.00 |
| 75-10691 | 2:5263 | NTIS, $4.25 |
| 75-10754 | 2:5281 | NTIS, $7.00 |
| 75-10772 | 2:5228 | NTIS, $9.50 |
| 75-10773 | 2:5229 | NTIS, $9.25 |
| 75-10943 | 2:5465 | NTIS, $4.75 |
| 75-11017/1ST | 2:4607 | NTIS, $3.75 |
| CONF-721018-31 | 2:4896 | *See* ANL-Trans-1072 |
| CONF-721246- | 2:6422 | Plenum Press (1974). |
| CONF-730871- | 2:5676 | *See* PB-243256 |
| CONF-740715- | 2:5725 | Academic Press, Inc. (1975). |
| CONF-750139- | 2:5202 | *See* JUL-Conf-15 |
| CONF-750410-11 | 2:5302 | University of Nebraska, Lincoln |
| 12 | 2:5519 | *See* ARH-SA-207 |
| CONF-750411-93 | 2:4574 | *See* ORNL-tr-4208 |
| CONF-750548- | 2:5675 | *See* NVO-159 |
| CONF-750641-4 | 2:4539 | *See* ERDA-tr-123 |
| CONF-750697-3 | 2:5171 | *See* SSI-1975-022 |
| CONF-750774- | 2:5307 | Elsevier Publishing Co., Inc. (1976). $37.50 |
| CONF-750806-(Absts.) | 2:4368 | Port City Press, Inc. (1975). $9.00 |
| CONF-750829-8 | 2:6057 | *See* RLO-1388-308 |
| 9 | 2:6080 | *See* RLO-1388-309 |
| 11 | 2:6056 | *See* RLO-1388-306 |
| 12 | 2:6079 | *See* RLO-1388-307 |
| 13 | 2:6054 | *See* RLO-1388-314 |
| 14 | 2:6048 | *See* RLO-1388-317 |
| CONF-750989-P2 | 2:6386 | Dep. NTIS, $13.50 |
| P4 | 2:6394 | Dep. NTIS, $12.00 |
| CONF-7509137-2 | 2:4379 | Institute of Gas Technology, Chicago, IL |
| CONF-7509142-1 | 2:5697 | *See* RLO-2227-T12-62 |
| CONF-751010-3 | 2:5588 | *See* BDX-613-1456 |
| CONF-751090-P2 | 2:4441 | National Coal Association (1975). |
| CONF-751238- | 2:5272 | Dep. NTIS, $6.00 |
| CONF-760137-1 | 2:5021 | Dep. NTIS, $4.00 |
| CONF-760310-17 | 2:4590 | *See* BNWL-tr-203 |
| CONF-760315-5 | 2:5715 | Dep. NTIS, $4.00 |
| CONF-760401-P3 | 2:4627 | American Chemical Society (1976). $4.00 |
| CONF-760407-4 | 2:5653 | *See* BNWL-SA-5528 |
| 5 | 2:5170 | *See* BNL-21066 |
| CONF-760414-3 | 2:5592 | *See* BDX-613-1535 |
| 4 | 2:5593 | *See* BDX-613-1536 |
| 5 | 2:5591 | *See* BDX-613-1532 |
| 6 | 2:5590 | *See* BDX-613-1524 |
| CONF-760421-8 | 2:6107 | Dep. NTIS, $3.50 |
| 9 | 2:6108 | Dep. NTIS, $3.50 |
| CONF-760431-4 | 2:6087 | *See* ORNL/TM-5530 |
| CONF-760503-13 | 2:5431 | Dep. NTIS, $3.50 |
| 15 | 2:4885 | Dep. NTIS, $4.00 |
| CONF-760525-2 | 2:5734 | *See* BNWL-SA-5644 |
| CONF-760539-6 | 2:5616 | *See* EGG-1183-2342 |
| CONF-760540-8 | 2:5311 | *See* Y/DA-6661 |
| 10 | 2:5334 | *See* Y/DA-6665 |
| 15 | 2:5330 | *See* SAND-76-8634 |

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| CONF-760568-1 | 2:5716 | Dep. NTIS, $3.50 |
| CONF-760601-10 | 2:5940 | See BNL-21404 |
| CONF-760609-9 | 2:5594 | See UCRL-77548(Rev.1) |
| CONF-760610-2 | 2:6133 | See UCRL-77974 |
| CONF-760631-4 | 2:5443 | See Y/DL-521 |
| 9 | 2:6344 | See BNL-21563 |
| CONF-760635-4 | 2:5712 | Dep. NTIS, $3.50 |
| CONF-760643-3 | 2:6421 | See BNL-21554 |
| 5 | 2:4729 | See LBL-5227 |
| CONF-760646-4 | 2:5432 | See BNL-21531 |
| CONF-760652-2 | 2:5176 | Dep. NTIS, $4.00 |
| CONF-760664-2 | 2:5851 | See UCRL-77651 |
| CONF-760669-1 | 2:6044 | See COO-3130TA-331 |
| CONF-760703-8 | 2:5200 | See BNL-21281 |
| CONF-760719-9 | 2:5991 | See BNL-21583 |
| 10 | 2:5976 | See BNL-21584 |
| 11 | 2:5992 | See BNL-21585 |
| 13 | 2:6013 | See COO-1195-377 |
| CONF-760731-2 | 2:5321 | Dep. NTIS, $3.50 |
| CONF-760733-2 | 2:6337 | See LA-UR-76-1724 |
| CONF-760801-3 | 2:5277 | See UCRL-77621(Rev.1) |
| CONF-760803-11 | 2:5421 | See SAND-76-5318 |
| CONF-760817-6 | 2:4378 | Dep. NTIS, $4.00 |
| CONF-760819-2 | 2:5447 | See SAND-75-5458 |
| 12 | 2:5414 | See DP-MS-75-88 |
| CONF-760822-16 | 2:5033 | Harvard Air Cleaning Lab., Boston, MA |
| 18 | 2:4582 | Harvard Air Cleaning Lab., Boston, MA |
| 19 | 2:4583 | Harvard Air Cleaning Lab., Boston, MA |
| 20 | 2:5541 | Dep. NTIS, $3.50 |
| CONF-760823-7 | 2:5316 | See LBL-5128 |
| CONF-760824-1 | 2:4732 | See UCRL-77938 |
| CONF-760826-7 | 2:4939 | Dep. NTIS, $4.00 |
| 8 | 2:4584 | Dep. NTIS, $4.00 |
| (Absts.) | 2:4369 | Port City Press, Inc. (1976). |
| CONF-760828-4 | 2:5553 | See UCRL-77739 |
| 6 | 2:6166 | See UCRL-77744 |
| 7 | 2:6167 | See UCRL-78422 |
| 8 | 2:6165 | See UCRL-77743 |
| CONF-760829-3 | 2:6345 | Dep. NTIS, $3.50 |
| 4 | 2:6346 | Dep. NTIS, $3.50 |
| 7 | 2:6347 | Dep. NTIS, $3.50 |
| 9 | 2:6348 | Dep. NTIS, $3.50 |
| 10 | 2:6349 | Dep. NTIS, $3.50 |
| 13 | 2:6352 | See UCRL-78463 |
| 16 | 2:5440 | See LA-UR-76-1861 |
| CONF-760832-10 | 2:6183 | See LA-UR-76-1687 |
| 13 | 2:5554 | See UCRL-78514 |
| CONF-760909-1 | 2:4734 | See SAND-76-5397 |
| CONF-760918-1 | 2:5652 | See BNL-21598 |
| CONF-760921-3 | 2:5438 | See SAND-76-5365 |
| CONF-760922-10 | 2:5343 | See BNL-21690 |
| 11 | 2:5450 | See BNL-21688 |
| 12 | 2:5342 | See BNL-21689 |
| CONF-760924-1 | 2:5597 | See LA-UR-76-1666 |
| CONF-760928-2 | 2:5322 | See LBL-4962 |
| CONF-760933-1 | 2:5166 | See BNL-21667 |
| CONF-761001-2 | 2:5054 | See SAND-76-5420 |
| CONF-761003-5 | 2:5654 | See BNWL-SA-5653 |
| 9 | 2:5651 | See BNL-21482 |
| 10 | 2:5658 | See DP-MS-76-5 |
| 11 | 2:5664 | See DP-MS-76-1 |
| 12 | 2:5655 | See BNWL-SA-5669 |
| 13 | 2:5663 | See BNWL-SA-5654 |
| 18 | 2:5657 | See COO-2455-9 |
| 19 | 2:5660 | See UCRL-78120 |
| CONF-761005-4 | 2:6336 | Dep. NTIS, $3.50 |
| CONF-761007-4 | 2:4748 | See BNL-21666 |
| CONF-761012-4 | 2:6139 | Dep. NTIS, $4.00 |
| CONF-761014-2 | 2:4585 | Dep. NTIS, $3.50 |
| CONF-761101-3 | 2:5572 | See UCRL-78208 |
| COO-1156-84 | 2:5687 | Dep. NTIS, $4.50 |
| 1195-377 | 2:6013 | Dep. NTIS, $3.50 |
| 1332-121 | 2:5694 | Dep. NTIS, $7.50 |
| 2185-10 | 2:5695 | Dep. NTIS, $7.50 |
| 2245-30 | 2:4886 | Dep. NTIS, $6.00 |
| 2250-22 | 2:4887 | Dep. NTIS, $3.50 |
| 2269-11 | 2:5743 | Dep. NTIS, $3.50 |
| 2277-8 | 2:6140 | Dep. NTIS, $5.00 |
| 2360-3 | 2:5656 | Dep. NTIS, $3.50 |
| 2426-50 | 2:4888 | AT |
| 2455-9 | 2:5657 | Dep. NTIS, $3.50 |
| 2456-36 | 2:6194 | Dep. NTIS, $6.00 |
| 2512-9 | 2:5087 | Dep. NTIS, $3.50 |
| 2538-20 | 2:5719 | Dep. NTIS, $3.50 |
| 2571-5 | 2:5088 | Dep. NTIS, $3.50 |
| 2735-1 | 2:6195 | Dep. NTIS, $3.50 |
| 2781-1 | 2:5089 | Dep. NTIS, $3.50 |
| 2781-2 | 2:5090 | Dep. NTIS, $3.50 |
| 2781-3 | 2:5091 | Dep. NTIS, $3.50 |
| 2801-2 | 2:5092 | Dep. NTIS, $3.50 |
| 2803-2 | 2:5093 | Dep. NTIS, $3.50 |
| 2904-1 | 2:4380 | Dep. NTIS, $3.50 |
| 3017-25 | 2:5744 | Dep. NTIS, $3.50 |
| 3017-26 | 2:5745 | Dep. NTIS, $3.50 |
| 3130TA-331 | 2:6044 | Dep. NTIS, $3.50 |
| 3134-9 | 2:5768 | Dep. NTIS, $5.00 |
| 3173-16 | 2:5722 | Dep. NTIS, $3.50 |
| 3214-11 | 2:5717 | Dep. NTIS, $5.00 |
| 3243-5 | 2:5728 | Dep. NTIS, $10.75 |
| 3409-6 | 2:5041 | Dep. NTIS, $5.00 |
| 3429-27 | 2:5352 | Dep. NTIS, $4.00 |
| 3435-20 | 2:5515 | Dep. NTIS, $6.00 |
| 3498-26 | 2:5502 | Dep. NTIS, $3.50 |
| 3531-11 | 2:5711 | Dep. NTIS, $3.50 |
| 3573-14 | 2:5696 | Dep. NTIS, $6.75 |
| 3573-15 | 2:5700 | Dep. NTIS, $9.25 |
| COO/2688-76/8 | 2:4674 | Dep. NTIS, $4.00 |
| COO/2693-76/1 | 2:4721 | See MTR-7137 |
| CRBRP-ARD-0115 | 2:5094 | AT |
| D-180-18768-1 | 2:5262 | See N-75-24802 |
| DERM-LL-74-1003 | 2:5733 | See AD-A-012703 |
| DME-MET-515 | 2:5278 | See AD-A-010986 |
| DP-MS-75-88 | 2:5414 | Dep. NTIS, $3.50 |
| 76-1 | 2:5664 | Dep. NTIS, $3.50 |
| 76-5 | 2:5658 | Dep. NTIS, $3.50 |
| DPSPU-73-124-1(Suppl.1) | 2:5549 | Dep. NTIS, $3.50 |
| DPST-76-125-1 | 2:4586 | Dep. NTIS, $3.50 |

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|---|---|---|
| **DST-** | | |
| 1850S-403-75 | 2:5283 | *See* AD-A-011129 |
| **E-** | | |
| 7988 | 2:4928 | *See* N-75-24843 |
| **EGG-** | | |
| 1183-1642 | 2:5688 | Dep. NTIS, $3.50 |
| 1183-2342 | 2:5616 | Dep. NTIS, $3.50 |
| **EPA-** | | |
| 440/1-74-009-a | 2:5702 | *See* PB-241905 |
| 450/3-74-066 | 2:5222 | *See* PB-242537 |
| 450/3-75-041 | 2:5216 | *See* PB-242022 |
| 450/3-75-042 | 2:5215 | *See* PB-242017 |
| 450/3-75-043 | 2:5212 | *See* PB-241933 |
| 670/4-75-006 | 2:5676 | *See* PB-243256 |
| 680/4-75/002a | 2:5179 | *See* PB-243696 |
| 680/4-75/002b | 2:5677 | *See* PB-243636/8ST |
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| 74-06(Vol.1) | 2:5180 | *See* PB-243805 |
| 75-01 | 2:5178 | *See* PB-243568 |
| **ERDA-** | | |
| 76-23 | 2:5765 | TIC |
| 76-65 | 2:5156 | Dep. NTIS, $11.00 |
| 76/115 | 2:6144 | Dep. NTIS, $6.75 |
| 76/123 | 2:5305 | Dep. NTIS, $6.00 |
| 116(Vol.10) | 2:6363 | Dep. NTIS, $6.00 |
| 1548 | 2:5595 | Dep. NTIS, $9.25 |
| 1550-D | 2:5680 | USERDA, Washington, DC |
| **ERDA-tr-** | | |
| 123 | 2:4539 | Dep. NTIS, $3.50 |
| **ESRO-TT-** | | |
| 123 | 2:4671 | *See* N-75-20878 |
| **EURFNR-** | | |
| 1295 | 2:4899 | Dep. NTIS, $4.00 |
| 1296 | 2:4900 | Dep. NTIS, $5.50 |
| 1318 | 2:5422 | Dep. NTIS, $4.00 |
| **FEA/D-** | | |
| 74/194 | 2:5197 | *See* PB-241820 |
| 75/283R | 2:5198 | *See* PB-241856 |
| **GA-A-** | | |
| 13801(Vol.1) | 2:4818 | Dep. NTIS, $10.00 |
| 13836 | 2:4819 | Dep. NTIS, $7.75 |
| 13861 | 2:4820 | Dep. NTIS, $4.50 |
| 13898 | 2:4821 | Dep. NTIS, $5.00 |
| **GAT-** | | |
| 225(Rev.3) | 2:4559 | Dep. NTIS, $5.50 |
| **GERHTR-** | | |
| 146 | 2:4862 | Dep. NTIS, $5.50 |
| 159 | 2:4822 | Dep. NTIS (US Sales Only), $4.00 |
| **GKSS-** | | |
| 76/E/29 | 2:4447 | Dep. NTIS (US Sales Only), $3.50 |
| 76/E/30 | 2:4448 | Dep. NTIS (US Sales Only), $3.50 |
| **GRU-** | | |
| 9DJ.75 | 2:4382 | *See* PB-243694 |
| **HASL-** | | |
| 300(Suppl.3) | 2:5466 | Dep. NTIS, $4.50 |
| 300(Suppl.4) | 2:5467 | Dep. NTIS, $6.00 |
| **HEDL-ARD-FRT-** | | |
| 1366 | 2:5042 | AT |
| 1555 | 2:5043 | AT |
| **HEDL-HWS-** | | |
| 1506B(Pt.4) (Rev.0) | 2:5057 | AT |
| **HEDL-PC-** | | |
| 1(Rev.1) | 2:5044 | Dep. NTIS, $4.00 |
| **HEDL-SI-** | | |
| 74-1 | 2:5045 | Dep. NTIS, $10.00 |
| **HEDL-TC-** | | |
| 68 | 2:5415 | Dep. NTIS, $3.50 |
| 260-6(Vol.2) | 2:4889 | AT |
| 687 | 2:5046 | Dep. NTIS, $4.00 |
| **HEDL-TI-** | | |
| 76019 | 2:5095 | AT |
| 76026 | 2:5096 | AT |
| **HEDL-TME-** | | |
| 75-49 | 2:5047 | AT |
| 76-11 | 2:5022 | AT |
| 76-22 | 2:4587 | Dep. NTIS, $5.00 |
| 76-25 | 2:4890 | AT |
| 76-51 | 2:5048 | AT |
| **HW-** | | |
| 74792 | 2:4571 | Dep. NTIS, $3.50 |
| **ICP-** | | |
| 1099 | 2:4588 | Dep. NTIS, $4.00 |
| **IDO-** | | |
| 12080 | 2:5706 | Dep. NTIS, $7.75 |
| **IIHR-** | | |
| 164 | 2:4739 | *See* PB-242406 |
| **IS-** | | |
| 3830 | 2:5477 | Dep. NTIS, $21.25 |
| 3974 | 2:5097 | Dep. NTIS, $4.50 |
| **IS-Trans-** | | |
| 94 | 2:5494 | Dep. NTIS, $3.50 |
| **ITC-** | | |
| 240576 | 2:4674 | *See* COO/2688-76/8 |
| **JUL-** | | |
| 1226 | 2:4822 | *See* GERHTR-159 |
| **JUL-Conf-** | | |
| 15 | 2:5202 | Dep. NTIS (US Sales Only), $7.60 |
| **K-TL-** | | |
| 524(Pt.5) | 2:4537 | Dep. NTIS, $4.00 |
| **KFK-PDV-** | | |
| 66 | 2:4477 | Dep. NTIS (US Sales Only), $4.00 |
| **KY-** | | |
| 672 | 2:5475 | Dep. NTIS, $4.50 |
| **LA-** | | |
| 6137-PR | 2:5098 | Dep. NTIS, $4.50 |
| 6278-MS | 2:5769 | Dep. NTIS, $3.50 |
| 6416-MS | 2:5770 | Dep. NTIS, $3.50 |
| 6433-MS | 2:4679 | Dep. NTIS, $3.50 |
| **LA-NUREG-** | | |
| 6326-MS | 2:5099 | Dep. NTIS, $3.50 |
| **LA-tr-** | | |
| 76-18 | 2:5602 | Dep. NTIS, $4.00 |
| 76-20 | 2:5323 | Dep. NTIS, $3.50 |
| **LA-UR-** | | |
| 76-1666 | 2:5597 | Dep. NTIS, $3.50 |
| 76-1687 | 2:6183 | Dep. NTIS, $3.50 |
| 76-1724 | 2:6337 | Dep. NTIS, $3.50 |
| 76-1861 | 2:5440 | Dep. NTIS, $3.50 |
| **LBL-** | | |
| 4962 | 2:5322 | Dep. NTIS, $3.50 |
| 5128 | 2:5316 | Dep. NTIS, $4.00 |
| 5129 | 2:5452 | Dep. NTIS, $6.75 |
| 5206 | 2:4752 | Dep. NTIS, $6.00 |
| 5227 | 2:4729 | Dep. NTIS, $3.50 |
| 5423 | 2:5329 | Dep. NTIS, $5.50 |
| **LMEC-** | | |
| 76-1 | 2:4891 | AT |
| **MATT-** | | |
| 1(Suppl.5) | 2:6134 | Dep. NTIS, $3.50 |
| 1274 | 2:6358 | Dep. NTIS, $4.00 |
| **MIT-EL-** | | |
| 74-014;195 | 2:5709 | *See* PB-242934 |
| 75-023 | 2:4738 | Dep. NTIS, $5.50 |
| 76-005 | 2:5107 | *See* ORNL-SUB-4450-1 |
| 76-008 | 2:5185 | Dep. NTIS, $3.50 |
| **MITSG-** | | |
| 74-19 | 2:5759 | *See* COM-74-11089/AS |
| **MLM-** | | |
| 2312 | 2:5476 | Dep. NTIS, $3.50 |
| 2322 | 2:5472 | Dep. NTIS, $3.50 |
| **MTR-** | | |
| 7137 | 2:4721 | Dep. NTIS, $4.00 |
| **N-** | | |
| 75-20799 | 2:4457 | NTIS, $4.25 |
| 75-20868 | 2:4634 | NTIS, $3.75 |
| 75-20878 | 2:4671 | NTIS, $4.25 |
| 75-21633 | 2:5287 | NTIS, $3.75 |
| 75-21796 | 2:4736 | NTIS, $4.75 |
| 75-22103 | 2:6109 | NTIS, $3.25 |
| 75-22229 | 2:5816 | NTIS, $3.25 |
| 75-22343 | 2:5798 | NTIS, $5.25 |
| 75-22745 | 2:5282 | NTIS, $8.75 |
| 75-22901 | 2:5303 | NTIS, $3.25 |
| 75-22902 | 2:5304 | NTIS, $7.50 |
| 75-22904 | 2:4737 | NTIS, $10.25 |
| 75-22938 | 2:5701 | NTIS, $3.25 |
| 75-23920 | 2:5817 | NTIS, $7.50 |
| 75-24122 | 2:4458 | NTIS, $8.50 |
| 75-24164 | 2:5665 | NTIS, $5.25 |
| 75-24439 | 2:5849 | NTIS, $3.25 |
| 75-24446 | 2:5509 | NTIS, $3.25 |
| 75-24477 | 2:4977 | NTIS, $3.25 |
| 75-24593 | 2:5629 | NTIS, $3.75 |

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| 75-24624 | 2:5819 | NTIS, $3.25 |
| 75-24625 | 2:5820 | NTIS, $3.25 |
| 75-24632 | 2:5818 | NTIS, $3.25 |
| 75-24802 | 2:5262 | NTIS, $10.00 |
| 75-24843 | 2:4928 | NTIS, $4.25 |
| 75-25785 | 2:5804 | NTIS, $9.25 |
| 75-25812 | 2:5781 | NTIS, $3.25 |
| 75-26482/0ST | 2:4538 | NTIS, $3.25 |
| 75-26557/9ST | 2:5825 | NTIS, $3.25 |
| 75-26937/3ST | 2:5799 | NTIS, $4.25 |
| 75-26939/9ST | 2:5805 | NTIS, $3.25 |
| 75-26942/3ST | 2:5782 | NTIS, $3.75 |
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| 137654 | 2:5303 | *See* N-75-22901 |
| 141856 | 2:5262 | *See* N-75-24802 |
| 142558 | 2:4457 | *See* N-75-20799 |
| 142821 | 2:4458 | *See* N-75-24122 |
| 142822 | 2:5665 | *See* N-75-24164 |
| 142875 | 2:5849 | *See* N-75-24439 |
| 142977 | 2:5804 | *See* N-75-25785 |
| 142984 | 2:5799 | *See* N-75-26937/3ST |
| 143039 | 2:5805 | *See* N-75-26939/9ST |
| 143082 | 2:4538 | *See* N-75-26482/0ST |
| 143696 | 2:5629 | *See* N-75-24593 |
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| 354(Vol.2) | 2:5282 | *See* N-75-22745 |
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| 66828 | 2:5818 | *See* N-75-24632 |
| 70873 | 2:5816 | *See* N-75-22229 |
| 70901 | 2:5781 | *See* N-75-25812 |
| 70917 | 2:5782 | *See* N-75-26942/3ST |
| 71717 | 2:5287 | *See* N-75-21633 |
| 71942 | 2:4977 | *See* N-75-24477 |
| 72652 | 2:4634 | *See* N-75-20868 |
| 72726 | 2:5701 | *See* N-75-22938 |
| NASA-TN-D- | | |
| 7891 | 2:4928 | *See* N-75-24843 |
| NASA-TT-F- | | |
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| 16173 | 2:6109 | *See* N-75-22103 |
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| 16276 | 2:5509 | *See* N-75-24446 |
| 16340 | 2:5820 | *See* N-75-24625 |
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| 16413 | 2:5825 | *See* N-75-26557/9ST |
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| 281 | 2:5473 | Dep. NTIS, $3.50 |
| NBS-SP- | | |
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| NBSIR- | | |
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| 21297 | 2:5100 | Dep. NTIS, $5.00 |
| NGPRP/CD- | | |
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| 21103 | 2:5101 | NTIS |
| 21171 | 2:5767 | GPO |
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| 004 | 2:5116 | NTIS, $3.50 |
| NSF- | | |
| 75-403 | 2:5666 | Dep. NTIS, $5.50 |
| 76-13 | 2:5227 | *See* NSF-RA-N-75-037I |
| NSF-RA-N- | | |
| 75-037I | 2:5227 | Dep. NTIS, $3.50 |
| NSF/RANN/SE/GI- | | |
| 34979/TR/75/1 | 2:4673 | National Science Foundation, Washington, DC |
| NUA-TM- | | |
| 1-74 | 2:5741 | *See* AD-A-012684 |
| NUREG- | | |
| 75/061 | 2:5230 | *See* PB-242718 |
| 0047-4 | 2:5102 | Dep. NTIS, $3.50 |
| 0103 | 2:4780 | NTIS |
| 766500 | 2:5053 | *See* SAND-76-0281 |
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| NUREG/PRDI- | | |
| 76/9 | 2:4930 | TIC, $3.50 |

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| NVO- | | |
| 159 | 2:5675 | Dep. NTIS, $7.50 |
| NVO/AEIC- | | |
| 76/1 | 2:5689 | *See* ORNL/EIS-91 |
| OITS- | | |
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| 75-31 | 2:6017 | *See* RLO-2041-147 |
| ORNL- | | |
| 4990 | 2:5630 | Dep. NTIS, $5.50 |
| 5142 | 2:4598 | Dep. NTIS, $6.75 |
| 5157 | 2:5308 | AT |
| 5170 | 2:5023 | AT |
| 5191 | 2:5735 | Dep. NTIS, $4.00 |
| 5204 | 2:4892 | AT |
| ORNL/CSD- | | |
| 4 | 2:5721 | Dep. NTIS, $4.00 |
| ORNL/CSD/TM- | | |
| 8 | 2:6413 | Dep. NTIS, $3.50 |
| ORNL/EIS- | | |
| 91 | 2:5689 | Dep. NTIS, $7.75 |
| 96 | 2:5760 | Dep. NTIS, $4.00 |
| ORNL/HUD/MIUS- | | |
| 6 | 2:5168 | Dep. NTIS, $9.00 |
| 20 | 2:5169 | Dep. NTIS, $7.50 |
| ORNL/MIT- | | |
| 210 | 2:4567 | Dep. NTIS, $4.00 |
| 212 | 2:4626 | Dep. NTIS, $4.00 |
| ORNL/NUREG/TM- | | |
| 29 | 2:5009 | Dep. NTIS, $6.00 |
| 33 | 2:5529 | Dep. NTIS, $4.00 |
| 35 | 2:5103 | Dep. NTIS, $4.50 |
| 41 | 2:5104 | Dep. NTIS, $4.00 |
| 45 | 2:4781 | Dep. NTIS, $4.50 |
| 50 | 2:5105 | Dep. NTIS, $3.50 |
| 54 | 2:5106 | Dep. NTIS, $3.50 |
| ORNL/RUS- | | |
| 18 | 2:5684 | Dep. NTIS, $5.00 |
| ORNL/Sub- | | |
| 2913-1 | 2:4992 | Dep. NTIS, $4.50 |
| 4450-1 | 2:5107 | Dep. NTIS, $6.00 |
| ORNL/TIRC- | | |
| 76/2 | 2:5762 | Dep. NTIS, $20.00 |
| ORNL/TM- | | |
| 4210 | 2:4893 | Dep. NTIS, $4.50 |
| 4511 | 2:5049 | AT |
| 4976 | 2:5718 | Dep. NTIS, $5.50 |
| 4977 | 2:5708 | Dep. NTIS, $5.50 |
| 5313 | 2:5032 | Dep. NTIS, $5.00 |
| 5319 | 2:5024 | AT |
| 5355 | 2:4894 | AT |
| 5404 | 2:4823 | Dep. NTIS, $4.00 |
| 5436 | 2:4824 | Dep. NTIS, $3.50 |
| 5436 | 2:4825 | Dep. NTIS, $3.50 |
| 5457 | 2:4589 | Dep. NTIS, $4.50 |
| 5467 | 2:5050 | Dep. NTIS, $4.00 |
| 5470 | 2:5232 | Dep. NTIS, $4.50 |
| 5501 | 2:4826 | Dep. NTIS, $4.50 |
| 5530 | 2:6087 | Dep. NTIS, $4.00 |
| 5542 | 2:6350 | Dep. NTIS, $4.00 |
| 5556 | 2:4572 | AT |
| 5599 | 2:6196 | Dep. NTIS, $3.50 |
| ORNL-tr- | | |
| 4090(DRAFT) | 2:4599 | Dep. NTIS, $3.50 |
| 4145 | 2:5570 | Dep. NTIS, $3.50 |
| 4195 | 2:5487 | Dep. NTIS, $3.50 |
| 4198 | 2:5510 | Dep. NTIS, $3.50 |
| 4208 | 2:4574 | Dep. NTIS, $3.50 |
| 4210 | 2:5707 | Dep. NTIS, $4.00 |
| 4213 | 2:5617 | Dep. NTIS, $3.50 |
| 4222 | 2:5511 | Dep. NTIS, $3.50 |
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| PATENTS-DE- | | |
| 1,281,512/C/ | 2:5249 | |
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| 1,596,166/C/ | 2:5251 | |
| 1,596,187/C/ | 2:5157 | |
| 1,596,230 | 2:5245 | |
| 1,671,696/C/ | 2:5246 | |
| 1,671,790/C/ | 2:5253 | |
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| 2,361,905/A/ | 2:5162 | |
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| 2,431,851/A/ | 2:4740 | |
| 2,434,193/A/ | 2:5161 | |
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| 2,216,006/A/ | 2:4560 | |
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| 7,500,854/A/ | 2:5014 | |
| 7,500,947/A/ | 2:4541 | |
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| 3,825,487 | 2:4642 | |
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| 3,836,344 | 2:4645 | |
| 3,838,993 | 2:4646 | |
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| 3,965,244 | 2:5482 | |
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| 3,966,258 | 2:4431 | |
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| 3,966,873 | 2:4554 | |
| 3,969,194 | 2:4603 | |
| 3,969,204 | 2:4566 | |
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| 3,969,484 | 2:5483 | |
| 3,970,581 | 2:4556 | |
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| **PB-** | | |
| 241507 | 2:5667 | NTIS, $4.75 |
| 241756 | 2:4744 | NTIS, $4.25 |
| 241785 | 2:4415 | NTIS, $4.25 |
| 241796 | 2:5208 | NTIS, $3.75 |
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| 241820 | 2:5197 | NTIS, $4.25 |
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| 241824 | 2:5177 | NTIS, $6.25 |
| 241845 | 2:4465 | NTIS, $7.00 |
| 241856 | 2:5198 | NTIS, $3.25 |
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| 241905 | 2:5702 | NTIS, $10.25 |
| 241918 | 2:4745 | NTIS, $8.50 |
| 241919 | 2:5260 | NTIS, $7.00 |
| 241930 | 2:5210 | NTIS, $4.25 |
| 241931 | 2:5211 | NTIS, $4.75 |
| 241933 | 2:5212 | NTIS, $3.25 |
| 241934 | 2:5213 | NTIS, $4.25 |
| 241935 | 2:5214 | NTIS, $3.25 |
| 242017 | 2:5215 | NTIS, $3.25 |
| 242022 | 2:5216 | NTIS, $3.25 |
| 242075-01/SL | 2:5668 | NTIS, $15.00 |
| 242091 | 2:5298 | NTIS, $4.75 |
| 242092 | 2:5294 | NTIS, $5.75 |
| 242093 | 2:5301 | NTIS, $6.25 |
| 242094 | 2:5295 | NTIS, $9.50 |
| 242097 | 2:5299 | NTIS, $8.50 |
| 242132 | 2:5217 | NTIS, $3.75 |
| 242135 | 2:5218 | NTIS, $4.25 |
| 242232 | 2:5280 | NTIS, $4.25 |
| 242246 | 2:5300 | NTIS, $4.25 |
| 242247 | 2:5296 | NTIS, $7.50 |
| 242306 | 2:5219 | NTIS, $4.25 |
| 242307 | 2:5220 | NTIS, $3.75 |
| 242308 | 2:5221 | NTIS, $3.75 |
| 242328 | 2:5037 | NTIS, $5.25 |
| 242406 | 2:4739 | NTIS, $4.25 |
| 242408 | 2:5261 | Specify tape recording mode desired: 9 track, 800 or 1600 bpi, odd parity, EBCDIC; or 7 track, 556 or 800 bpi, odd or even parity, BCD. Documentation available. |
| 242461 | 2:4456 | NTIS, $5.75 |
| 242465 | 2:4407 | NTIS, $8.50 |
| 242515 | 2:4746 | NTIS, $7.00 |
| 242537 | 2:5222 | NTIS, $4.25 |
| 242595 | 2:4381 | NTIS, $7.25 |
| 242718 | 2:5230 | NTIS, $4.25 |
| 242751 | 2:4446 | NTIS, $10.50 |
| 242774 | 2:4635 | NTIS, $6.25 |
| 242934 | 2:5709 | NTIS, $5.75 |
| 242983 | 2:5690 | NTIS, $3.75 |
| 243151 | 2:4367 | NTIS, $7.25 |
| 243256 | 2:5676 | Dep. NTIS, $4.50 |
| 243318 | 2:5183 | NTIS, $3.75 |
| 243347/2ST | 2:4451 | NTIS, $4.75 |
| 243509 | 2:5686 | NTIS, $3.75 |
| 243568 | 2:5178 | NTIS, $12.00 |
| 243636/8ST | 2:5677 | NTIS, $3.75 |
| 243694 | 2:4382 | NTIS, $4.25 |
| 243696 | 2:5179 | NTIS, $3.25 |
| 243805 | 2:5180 | NTIS, $17.25 |
| **PIFR-** | | |
| 863 | 2:6359 | Dep. NTIS, $4.00 |
| **Pub-** | | |
| 25 | 2:5037 | *See* PB-242328 |
| 97 | 2:5520 | Dep. NTIS, $6.75 |
| **RDT-M-** | | |
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| 10.4(07-76) | 2:4611 | NUREG |
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| 2525 | 2:5606 | Dep. NTIS, $4.00 |
| **RFP-NUREG-** | | |
| 2555 | 2:5521 | Dep. NTIS, $4.00 |
| **RFP-Trans-** | | |
| 196 | 2:5485 | Dep. NTIS, $3.50 |
| 197 | 2:5488 | Dep. NTIS, $3.50 |
| 203 | 2:5491 | Dep. NTIS, $3.50 |
| **RL-** | | |
| 75-176 | 2:6010 | Dep. NTIS, $3.50 |
| **RLO-** | | |
| 1388-306 | 2:6056 | Dep. NTIS, $3.50 |
| 1388-307 | 2:6079 | Dep. NTIS, $3.50 |
| 1388-308 | 2:6057 | Dep. NTIS, $3.50 |
| 1388-309 | 2:6080 | Dep. NTIS, $3.50 |
| 1388-314 | 2:6054 | Dep. NTIS, $3.50 |
| 1388-317 | 2:6048 | Dep. NTIS, $3.50 |
| 2041-147 | 2:6017 | Dep. NTIS, $3.50 |
| 2041-148 | 2:6045 | Dep. NTIS, $3.50 |
| 2225-T24-18 | 2:5703 | Dep. NTIS, $3.50 |

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|---|---|---|
| 2225-T39-1 | 2:5692 | Dep. NTIS, $4.50 |
| 2227-T12-62 | 2:5697 | Dep. NTIS, $3.50 |
| **RR-** | | |
| 12 | 2:5280 | *See* PB-242232 |
| **RSC-** | | |
| 08 | 2:4457 | *See* N-75-20799 |
| **RSR-** | | |
| 75-2 | 2:4538 | *See* N-75-26482/0ST |
| **SAND-** | | |
| 75-0657 | 2:5051 | Dep. NTIS, $6.75 |
| 75-5458 | 2:5447 | Dep. NTIS, $3.50 |
| 76-0161 | 2:5052 | Dep. NTIS, $5.00 |
| 76-0200 | 2:5025 | Dep. NTIS, $4.00 |
| 76-0273 | 2:5108 | Dep. NTIS, $4.00 |
| 76-0281 | 2:5053 | Dep. NTIS, $4.00 |
| 76-0359 | 2:5453 | Dep. NTIS, $3.50 |
| 76-0374 | 2:5850 | Dep. NTIS, $3.50 |
| 76-5318 | 2:5421 | Dep. NTIS, $3.50 |
| 76-5365 | 2:5438 | Dep. NTIS, $3.50 |
| 76-5397 | 2:4734 | Dep. NTIS, $3.50 |
| 76-5420 | 2:5054 | Dep. NTIS, $3.50 |
| 76-6028 | 2:5457 | Dep. NTIS, $4.00 |
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| 385/005 | 2:5552 | *See* UCRL-13655 |
| **SRD-** | | |
| 75-068 | 2:5615 | *See* CH-3193-3 |
| **SRO-** | | |
| 641-22 | 2:5756 | Dep. NTIS, $4.00 |
| 901-1 | 2:5698 | Dep. NTIS, $3.50 |
| **SSI-** | | |
| 1975-022 | 2:5171 | Dep. NTIS (US Sales Only), $3.50 |
| **SU-** | | |
| 326P38X4 | 2:5331 | Dep. NTIS, $3.50 |
| 326P38X5 | 2:5332 | Dep. NTIS, $4.50 |
| **TEC-** | | |
| 75/006b | 2:5193 | Dep. NTIS, $7.60 |
| 75/006c | 2:5174 | Dep. NTIS, $10.60 |
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| 27120 | 2:5265 | Dep. NTIS, $8.00 |
| **TT-** | | |
| 74-54003/9 | 2:4969 | *See* AEC-tr-7533/9 |
| **UCID-** | | |
| 17144 | 2:5646 | Dep. NTIS, $4.00 |
| 17149 | 2:6366 | Dep. NTIS, $3.50 |
| 17165 | 2:5631 | Dep. NTIS, $4.00 |
| 17170 | 2:4726 | Dep. NTIS, $3.50 |
| 17201 | 2:6222 | Dep. NTIS, $4.00 |
| 17203 | 2:5659 | Dep. NTIS, $4.00 |
| 17209 | 2:4727 | Dep. NTIS, $3.50 |
| 17226 | 2:5306 | Dep. NTIS, $4.00 |
| 17236 | 2:6360 | Dep. NTIS, $3.50 |
| 17243 | 2:5669 | Dep. NTIS, $4.00 |
| 17244 | 2:6145 | Dep. NTIS, $3.50 |
| 17252 | 2:6414 | Dep. NTIS, $4.00 |
| **UCLA-ENG-** | | |
| 7425 | 2:5766 | Dep. NTIS, $4.50 |
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| 13655 | 2:5552 | Dep. NTIS, $4.00 |
| 13665 | 2:5779 | Dep. NTIS, $4.00 |
| 50016-76-2 | 2:6351 | Dep. NTIS, $4.00 |
| 50028-76-2 | 2:5310 | Dep. NTIS, $4.50 |
| 50034-76-3 | 2:4735 | Dep. NTIS, $3.50 |
| 50039-76-1 | 2:6367 | Dep. NTIS, $3.50 |
| 51930(Vol.2) | 2:5764 | Dep. NTIS, $5.50 |
| 51930(Vol.3) | 2:5670 | Dep. NTIS, $5.00 |
| 52044 | 2:5448 | Dep. NTIS, $4.00 |
| 52045 | 2:5474 | Dep. NTIS, $3.50 |
| 52082 | 2:5840 | Dep. NTIS, $4.00 |
| 52093 | 2:5416 | Dep. NTIS, $4.50 |
| 77548(Rev.1) | 2:5594 | Dep. NTIS, $3.50 |
| 77621(Rev.1) | 2:5277 | Dep. NTIS, $4.00 |
| 77651 | 2:5851 | Dep. NTIS, $3.50 |
| 77739 | 2:5553 | Dep. NTIS, $3.50 |
| 77743 | 2:6165 | Dep. NTIS, $3.50 |
| 77744 | 2:6166 | Dep. NTIS, $3.50 |
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| 78120 | 2:5660 | Dep. NTIS, $3.50 |
| 78208 | 2:5572 | Dep. NTIS, $3.50 |
| 78422 | 2:6167 | Dep. NTIS, $3.50 |
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| **UCRL-Trans-** | | |
| 1526 | 2:5761 | Dep. NTIS, $3.50 |
| 11132 | 2:4386 | Dep. NTIS, $3.50 |
| 11133 | 2:4393 | Dep. NTIS, $3.50 |
| 11138 | 2:4416 | Dep. NTIS, $3.50 |
| 11140 | 2:4394 | Dep. NTIS, $4.00 |
| 11141 | 2:4387 | Dep. NTIS, $4.00 |
| 11143 | 2:4388 | Dep. NTIS, $3.50 |
| 11145 | 2:4395 | Dep. NTIS, $4.00 |
| 11151 | 2:4391 | Dep. NTIS, $3.50 |
| 11152 | 2:4389 | Dep. NTIS, $3.50 |
| 11154 | 2:4383 | Dep. NTIS, $3.50 |
| 11158 | 2:4385 | Dep. NTIS, $3.50 |
| 11159 | 2:4384 | Dep. NTIS, $3.50 |
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| 3490-946 | 2:5720 | Dep. NTIS, $7.50 |
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| 3045-18 | 2:4895 | AT |
| **WASH-** | | |
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